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M.V. ARCTIC
INSTRUMENTATION AND DATA COLLECTION SYSTEM

FOR

SHIP OPERATIONS IN ICE

**

SYSTEM OPERATING AND USER'S MANUAL

VOLUME I
(OPERATING INSTRUCTIONS)

FENCO CONSULTANTS LTD.
in conjunction with
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17. Abstract

The report provides an updated description of an Instrumentation and Data Collection System installed in the motor vessel "Arctic". This system is designed to provide a record of the ship's operational experience when navigating in ice, both in terms of the prevailing environmental conditions and the ship's performance and response. Records of hull strains resulting from ice impacts, together with ship machinery parameters (such as shaft RPM, fuel rack settings, torque, thrust and propeller pitch) and ship speed, direction and motions are obtained with this system. A computer-controlled time-division-multiplex system is used to sample the analogue output of each sensor, convert to digital form, and record on magnetic tape. Recording can be started manually or set to start automatically when specified signals exceed preset threshold levels. This report contains complete user information for operating the system and for carrying out routing hardware maintenance and software changes.

Volume 1 - Provides a general description of the system with operating and calibrating instruction, and a discussion of sampling schemes.

Volume 2 - Provides a detailed description of the hardware components including the CCTV System, along with manufacturer's information.

Volume 3 - Provides an introduction to the Rolm 1603A Computer, with details of the data acquisition and playback programs.

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PART I

GENERAL DESCRIPTION OF INSTRUMENTATION AND DATA COLLECTION SYSTEM

PART 1

GENERAL DESCRIPTION OF INSTRUMENTATION AND DATA COLLECTION SYSTEM

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Table 1 - M.V. ARCTIC - LEADING PARTICULARS

Length Overall	209.55 metres
Length Between Perpendiculars	196.60 m.
Moulded Draught	22.86 m.
Moulded Depth	15.24 m.
Moulded Breadth	10.97 m.
Summer Draught	10.82 m.
Block Coefficient	0.753
Prismatic Coefficient	0.761
Light Ship	9,276.1 tonnes
Displacement at 10.82 m. draught	37,724.1 t.
Dead Weight at 10.82 m. draught	28,448.0 t.
Cargo Capacity	36,490.8 cubic metres
Propulsion Machinery - MAN Diesel	11,014 kilowatts
Generators	900 kw x 3
Complement	40
Speed on Trials	15.5 knots
Cruising Range	14,000 Nautical miles

GENERAL DESCRIPTION OF THE SYSTEM

1. Introduction

In order to extend knowledge of ship operations in ice, the Transportation Development Agency of the Ministry of Transport initiated, in 1977, a comprehensive test program. Basic to this program is the Motor Vessel ARCTIC, a Class 2 commercial, ice-breaking, bulk cargo carrier (for leading particulars, see Table 1). This is an ocean-going vessel and intended to operate in the Canadian Arctic during the Summer season, and in the Great Lakes, Gulf of St. Lawrence and world-wide at other times. It will thus be operating in ice conditions for several months of the year. To utilize this potential, the following objectives were set:

2. Objectives

a) To provide an instrumentation system suitable for evaluating the structural strenght standards and other design criteria assumed to be necessary in the Arctic Shipping Pollution Prevention Regulations for a vessel of Class II, and permitting a quantitive and qualitative appraisal of these standards for other classes of icebreaking cargo vessels envisaged by these Regulations.

b) To record scientifically environmental conditions during the open Arctic shipping season, for subsequently evaluating, on the basis of the data obtained, the restraints on seasonal operational periods and zones currently established in the regulations for a vessel of Arctic Class II.

c) To provide an instrumentation system suitable for establishing a co-relation between the performance of a tank-tested model of the vessel in ice and that of the actual vessel under Arctic operational conditions. The instrumentation system shall therefore be capable of providing all data required to establish the vessel's icebreaking performance under actual and diverse operational conditions. This research will enable predictions to be made from future model tests of a full scale vessel's icebreaking efficiency under actual and diverse operational conditions of weather and ice intensity.

d) To provide suitable instrumentation for evaluating the degree of effectiveness, under various operational conditions, of special features incorporated into the initial design of the proposed vessel, such as an air bubbling system to reduce the frictional effects of broken ice.

3. Data Collection System

To obtain the comprehensive data essential to the project, an instrumentation system was required which would make appropriate measurements throughout the ship, process the sensor signals and store them on tape for later printout in appropriate SI units. This system was to operate in a manual or an automatic mode and to be capable of being programmed to sample all or any combination of available sensors. Measurements were required in five specific areas, as follows:

Hull Structure

Propulsion Machinery

Auxiliary Systems

Ship Performance

Environment

The system chosen consists essentially of the following elements (see figure 2),

a) Seven groups of sensors, which are connected to -

b) Seven junction boxes, which contain power supplies for sensor excitation (where required) and printed circuit boards for signal conditioning. These boxes are connected by -

c) A data bus, a 16 pair armoured cable forming a loop and thus providing some protection against data loss due to a cable break. This bus connects to -

d) A computer system, through the main interface, both of which are located in the laboratory on the port side, aft.

e) A closed circuit television system is also included.

A schematic drawing of the data acquisition system (4 sheets) is provided in Part III, Section 1 of this Manual. Main power, 115 volt 60 Hz, is provided from the ship's electrical system.

The most important measurements, as well as the most difficult to obtain, relate to the hull structure, where measurements of strain and temperature are required. A preliminary and comprehensive theoretical study was carried out in order to decide the number and locations of strain gauges to be used to provide suitable data, and the gauges were installed during the final stages of the construction of the ship.

The majority of the strain gauges are located on the starboard side, forward, in order to obtain a detailed picture of the behavior of the structure during ice navigation. A smaller number has been located on the port bow, close to the water line, for the purpose of recording the presence of growler impacts as well as to provide additional information on structural strains.

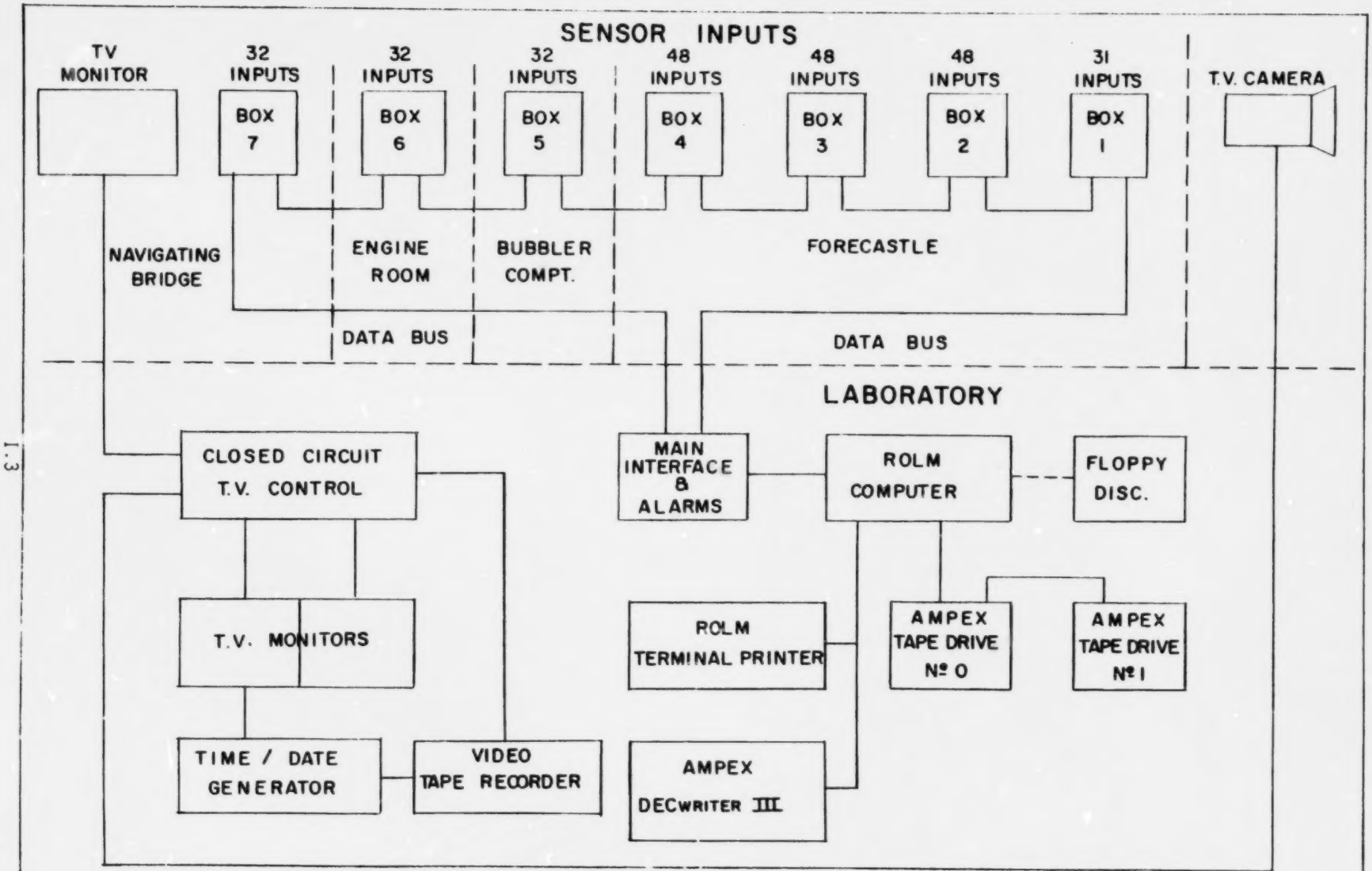


FIGURE 2 BLOCK DIAGRAM OF THE DATA COLLECTION SYSTEM.

In ther midships area, gauges were provided to measure field pressure. The distribution of the gauges is given in Table 2, below, and drawings showing the locations of the strain gauges and thermistors are provided in Part III, Section 2 of this Manual.

Table 2. DISTRIBUTION OF GAUGES

Secondary Frames		85
Outer Shell		42
Web Frames	Stbd.	4
Stringers		4
Inner Shell		4
Port Side		20
Midships		10
	Total	169

After installation, calibration testing of the gauges was carried out while the ship was berthed in the Welland Canal. For this purpose a special loading beam was attached to the ship's side and a jack used to apply known loads at various predetermined points.

Details of the rationale behind the selection of gauge locations, the calibration tests and the mathematical treatment is covered in a study paper entitled "METHODOLOGY AND APPROACH TO DEVELOPING CONVERSION PROGRAMS FOR ICE LOADS."

The strain gauges are of the hermetically sealed type, and are welded to the ship structure. They are self compensated for temperature. After installation they are covered with the same coating used to protect the ballast tanks. The thermistors are also hermetically sealed, weldable gauges which are mechanically similar to the strain gauges.

For further information on Hull Instrumentation, see Part III, Section 2 of this Manual.

Measurements related to the propulsion machinery are required only where they relate directly to ship performance. These are as follows:

a) Engine RPM - tap from ship's engine tachometer

b) Shaft RPM - tap from ship's shaft tachometer

c) Shaft Torque - Torquemeter supplied as part of data collection system

d) Propeller Command, Control and Response - connections to ship's command controller, response indicator and oil distribution box

e) Fuel Rack - connection to rack on main engine

f) Thrust - thrust meter supplied as part of data collection system

Calculations of fuel consumption and propeller blade spindle torque are performed by the computer.

Further details on Propulsion Machinery Instrumentation will be found in Part III, Section 3.

The ship is fitted with a pneumatic thruster/bubbler system, and instrumentation has been provided to monitor the performance of this equipment. In order that the system output can be computed for either thruster or bubbler mode, measurements of the following are made:

a) Bubbler Manifold Pressures - pressure transducers fitted to system

b) Bubbler Valve Positions - taps from the bubbler system control panel

c) Ship's Draught (Fore and Aft) - manual inputs

The Bubbler System Instrumentation is described in Part III, Section 4

Measurement of ship performance relates to the following:

a) Ship's Speed - Doppler Log supplied as part of data collection system

b) Pitch and Roll - vertical gyro supplied as part of data collection system

c) Ship's Head - taps from ship's compass

d) Rudder Command, Torque and Angle - connections to ship's indicators and hydraulic steering gear

e) Accelerators (Heave, Surge and Sway) - accelerometers (sets forward and aft).

Certain environmental conditions are recorded by manual inputs through selectors on the navigating bridge. Readings from conventional instrumentation transferred to the selectors in this way relate to:

a) Air Temperature

b) Relative Humidity

c) Barometric Pressure

d) Visibility

e) Cloud Cover

f) Ice Cover

Two other measurements are obtained directly from the outputs of a wind vane and anemometer, namely:

g) Wind Direction

h) Wind Speed

For further details of Environmental Sensing, see Part III Section 6.

The configuration of the system permits the use of 256 data channels and advantage has been taken of the speed of the computer to use Time Division Multiplexing, in which data channels are interrogated successively for a short period each. System sampling rate can be over 2,000 channels per second, with an individual channel rate as short as 1/1000 second. Only two wires, in a twisted, shielded configuration, are required to transmit analog data to the computer.

The junction boxes are numbered 1 to 7 and contain a total of 16 groups or bins, each of which serves 16 data input channels. The distribution of the bins is as follows:

Junction Box	Location	No. of Bins
1	Forecastle	2
2	Forecastle	3
3	Forecastle	3
4	Forecastle	3
5	Bubbler Compt.	1
6	Engine Room	2
7	Nav. Bridge	2

Addressing of an individual sensor is by bin and then by channel within the selected bin. However, for simplicity channels have been numbered 1 to 255. Channel 0 (Box 1, Bin 0, Card 0) is not a valid address.

The signal conditioning card for each channel in the junction boxes includes a unique code or "address" which responds to a specific signal from the computer. A digital, high-level, parallel addressing system has been used to select the individual channels, and eight of the data bus lines are used to carry an "address" coded in binary form. Eight lines permit a total of 256 unique codes to be handled. A ninth line is available to permit future expansion of the system.

Sensor inputs are amplified by individual circuit cards and, at any instant, only one output is on the return line to the laboratory.

This specific output results from a unique address placed on the data bus by the computer in response to channel selection by the operator or program. Change of address results in the selection of a different sensor and a corresponding change in output signal.

The sequential signals transmitted through the data bus are in digital form for the address but in analog form for the data output. Before the output signal can be accepted by the computer, it must be converted to digital form. This is accomplished by an analog to digital converter at the interface.

The interface actually performs several functions, as follows:

i) Amplification of low power "address" signals from the computer by driver circuits to full bus power level.

ii) Analog to digital conversion of data output signals.

iii) Alarm level setting of strain gauge data channels.

iv) "Fail safe" completion of timing in event of a conversion failure.

These are dealt with in more detail in Part III, Section 7.

The digital data signals received by the computer are checked, formatted and recorded on magnetic tape. If required, a printout can be made at the terminal.

There are two distinct computer programs - the data acquisition program and the playback program. Only one can operate at any given time.

The data acquisition program has been designed for fully automatic operation and to be run by non-computer oriented personnel with a minimum of training. It is designed to:

a) collect sensor data and store it on tape,

b) permit limited viewing of the data via hardcopy printout while it is being collected.

The operator is free to select the sampling pattern to suit any particular requirement. For example, as in monitoring, he may be interested in one channel only, while in the case of actual ice trials he may wish to record all available data. He may also select the rate at which any channel is sampled and the mode of sampling - Peak Holding or Real; Recording or Standby.

Once data gathering is started, the sampling of sensors is continuous. However, the recording of data to tape is optional.

Continuous recording mode may be selected, whereby all data collected is written to tape. This may be useful for calibration and testing, but in general will record masses of uninteresting data. Consequently, a

standby option has been provided. In the standby mode, any or all sensors may be assigned "alarm limits" to distinguish interesting values from uninteresting ones. As long as no sensor exceeds its alarm limits, no data is recorded on tape, although the sensors are sampled continuously. When any sensor exceeds its alarm limit, recording is started and continues for a pre-selected interval (30 seconds, for example), after which the program reverts again to standby, sampling but not recording. In standby mode, one second's worth of data is recorded to tape every hour, to provide static load and other information.

Until the operator halts data gathering, the sampling and recording of data takes precedence over other functions. Nevertheless, it is possible to verify operation of the system via two printout options which operate concurrently with data gathering:

a) Monitoring

   Any sensor may be selected for continuous printout and a value is typed periodically at a rate dependent on printer speed limitations. This is useful for checking a sensor which may be expected to vary over a period of seconds. It is not capable of reflecting changes occurring at faster rates due to printer speed limitations.

b) Logging

   In the absence of monitoring, logging printout is typed. One value for every sensor is typed at an interval selected by the operator (every 2 hours, for example). This is useful as a permanent record that the system was working, and also as a check on the proper functioning of the sensors. All values exceeding their alarm limits are flagged on the printout and a careful check should be made of readings on sensors that are not alarmed to ensure that they are reasonable.

The playback program provides a limited capability for reviewing recorded data. The tape may be searched by alarm limits, or by date and time, to locate an area of interest. When this is located, the operator may proceed in one of three modes:

a) Monitoring mode prints all values or every Nth value (N selected by the operator) of one selected sensor. Statistics are also accumulated.

b) Dump mode prints every value recorded. This mode will be used only for debugging and system verification, since it takes up to an hour to print one second's worth of data. Statistics are also accumulated.

c) Statistics mode: No printout occurs as the tape is read. Statistics are accumulated.

Analysis of accumulated statistics is intended to be carried out ashore.

Further details on the operation of the data gathering system will be found in the Operating Instructions which form Part II of this Manual.

As an additional feature, a closed circuit television system has been included, the purpose of which is as follows:

a) To provide a visual record of the ice interaction with the hull which may be correlated with the strain guage readings.

b) To provide general visual information concerning the environmental conditions such as ice coverage, snow coverage and visibility.

c) To provide a 180^{o} pan (beam/bow/beam) of the ship surroundings when triggered by the computer in the AUTO mode.

A video monitor is provided on the bridge for the benefit of the ship's operating personnel.

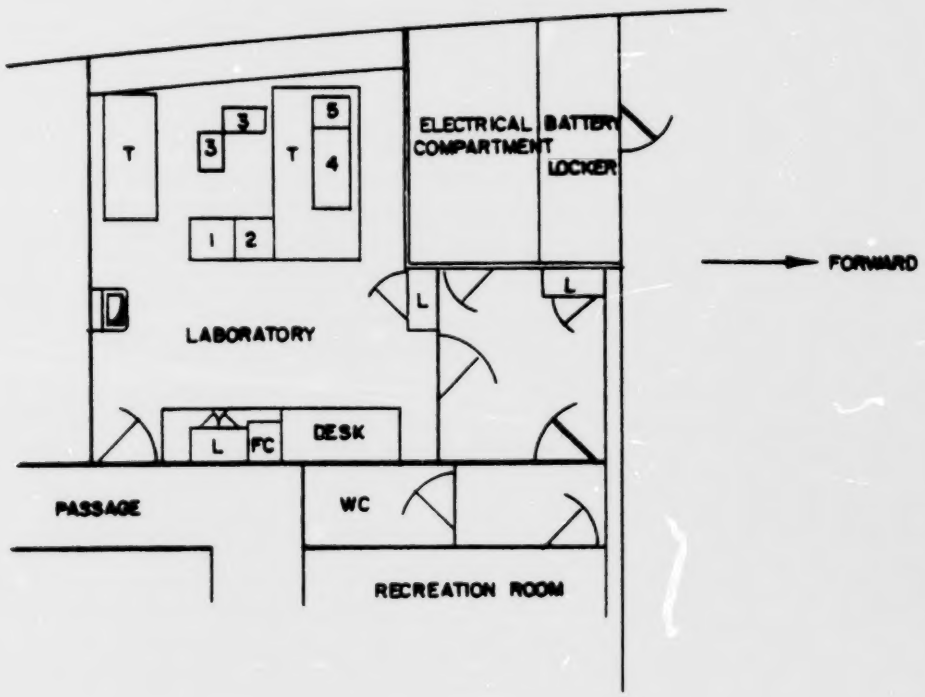
The camera is normally mounted on top of the lookout at the forward masthead. In this position it is remotely controlled, either manually or automatically. Alternate mounts are provided, two on the forecastle, starboard side, and one right at the stern on the poopdeck. These three locations have no provision for automatic operation.

A video recorder is provided, on which the display may be recorded at any time. In the automatic mode, the system is activiated by computer command related to the alarm level. Time/date information appears on every frame to permit correllation of video and data tape records.

For details of the Closed Circuit Television System see Part III, Section 8.

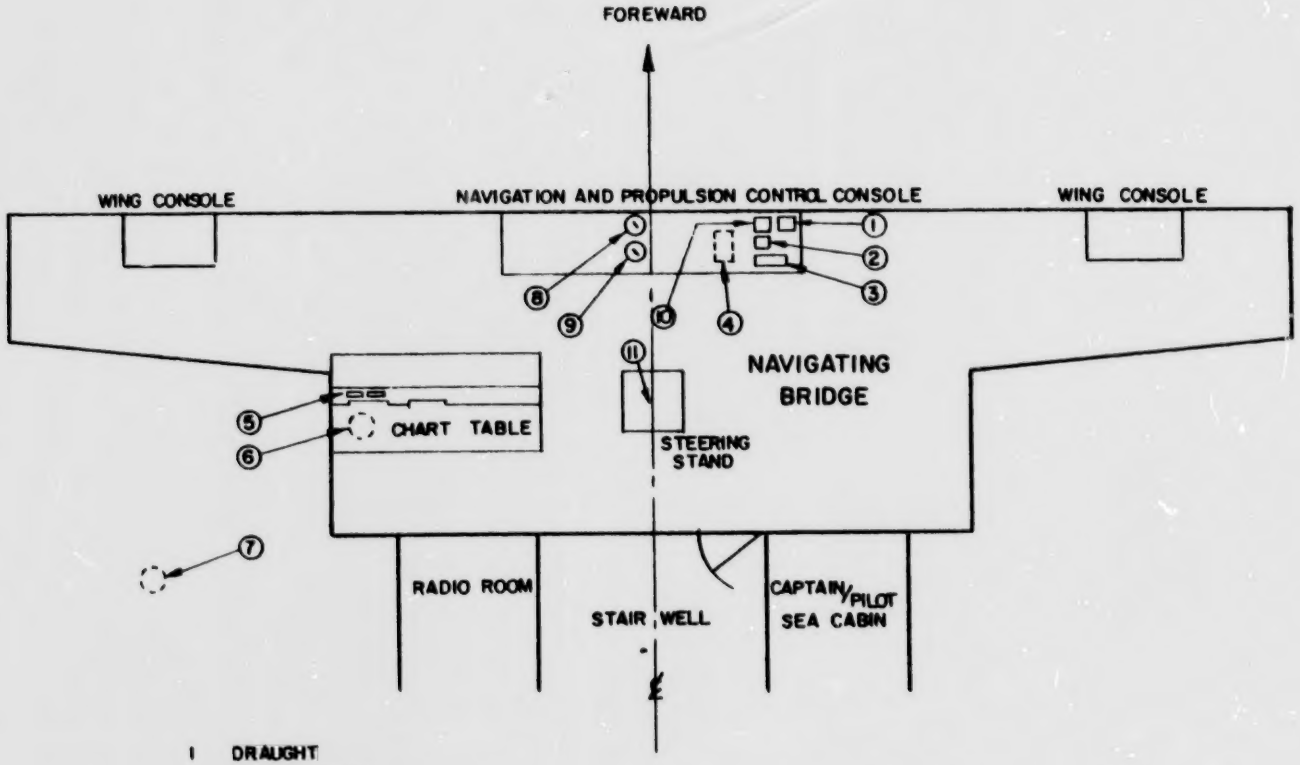
1 COMPUTER RACK
2 COMPUTER RACK
3 COMPUTER TERMINAL
4 C.C.T.V. CONTROLS AND MONITORS
5 VIDEO TAPE RECORDER

FC. FILING CABINET
L. LOCKER
T. TABLE
W.C. WATER CLOSET

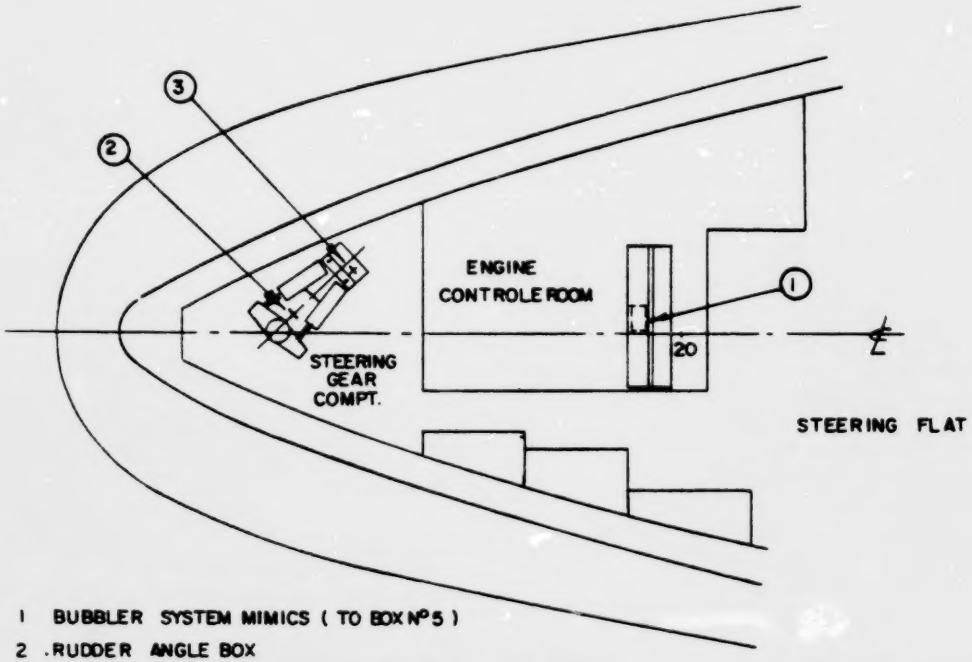


M.V. ARCTIC – LABORATORY

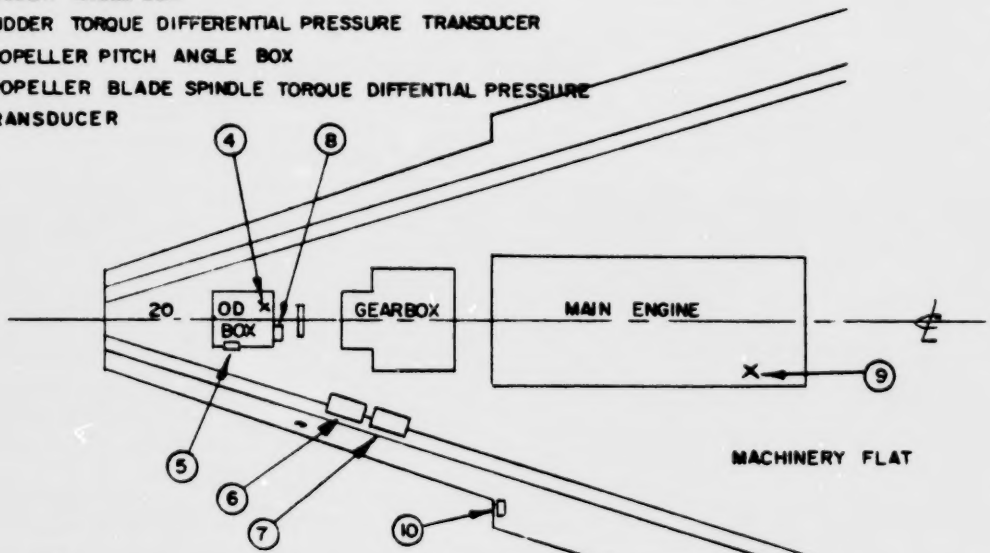
M.V. ARCTIC – NAVIGATING BRIDGE



1 DRAUGHT
2 CCTV MONITOR
3 INPUT CONTROLS FOR AIR TEMP, BAROMETRIC PRESS, RELATIVE HUMIDITY, VISIBILITY, CLOUD COVER, ICE COVER
4 BOX Nº7 (UNDER)
5 WIND DIRECTION AND VELOCITY INDICATORS (VANE AND ANEMOMETER ON MAST, STBD. AFT CORNER OF BRIDGE DECK)
6 GYRO COMPASS
7 PITCH/ROLL GYRO LOCATED IN LABORATORY CONNECTS TO BOX* 7
8 ENGINE R.P.M.
9 SHAFT RPM.
10 DOPPLER LOG
11 RUDDER COMMAND



1 BUBBLER SYSTEM MIMICS (TO BOX Nº 5)
2 RUDDER ANGLE BOX
3 RUDDER TORQUE DIFFERENTIAL PRESSURE TRANSDUCER
4 PROPELLER PITCH ANGLE BOX
5 PROPELLER BLADE SPINDLE TORQUE DIFFENTIAL PRESSURE TRANSDUCER



6 BOX Nº 6
7 RENK THRUST MEASUREMENT BOX
8 TORQUEMETER
9 FUEL RACK SETTING BOX
10 ACCELEROMETERS

M.V. ARCTIC – STEERING AND MACHINERY FLATS

8/1979

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SYSTEM OPERATING AND USER'S MANUAL

PART 11

OPERATING INSTRUCTIONS

PART II - OPERATING INSTRUCTIONS

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SECTION 1

INTRODUCTION TO OPERATION

SECTION 1 INTRODUCTION TO OPERATION

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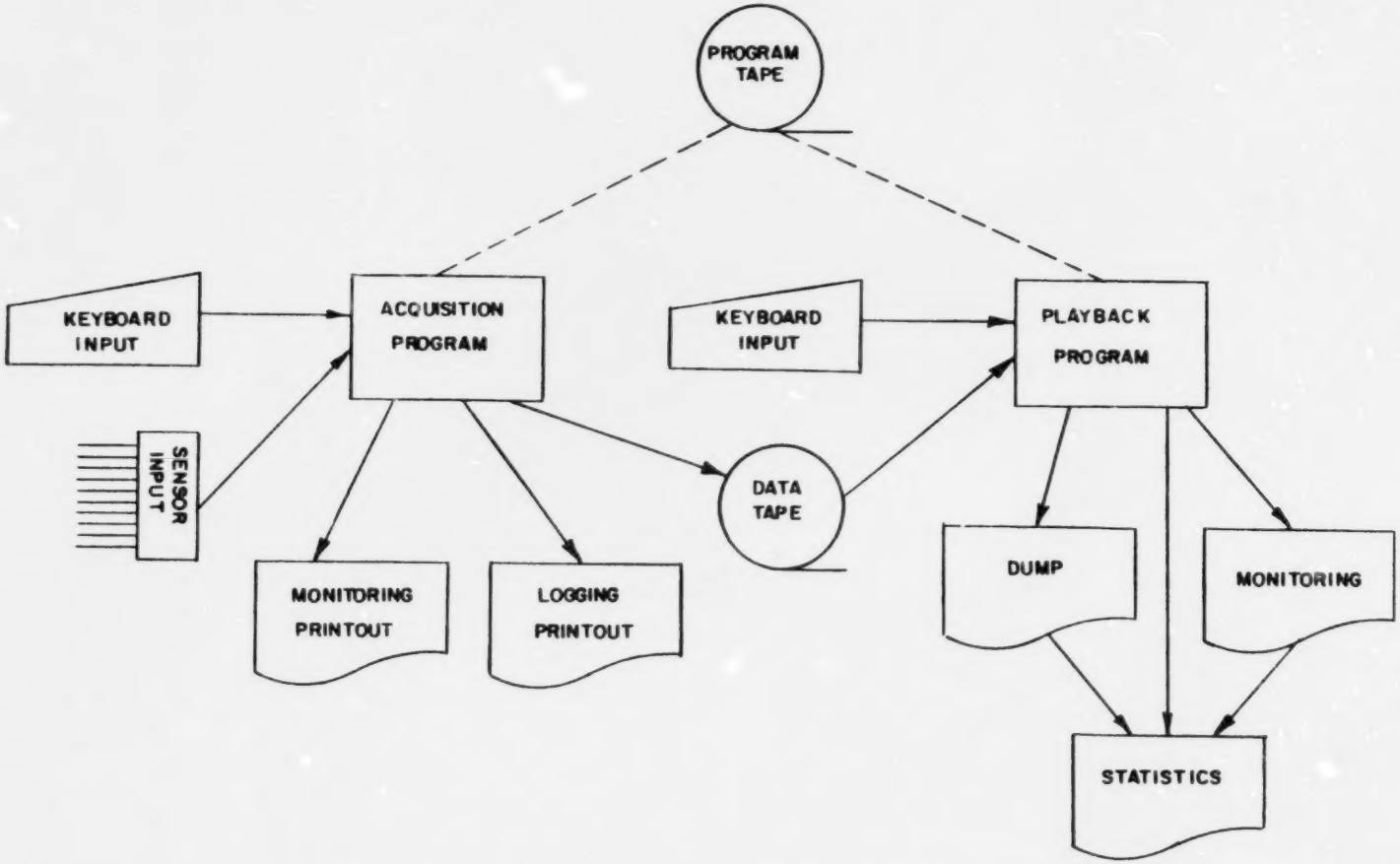

DATA GATHERING SYSTEM

SECTION 1 INTRODUCTION TO OPERATION

1. Introduction

The data gathering system comprises two distinct programs - the data acquisition program and the playback program. Only one can operate at any given time; while acquiring data, no playback is possible, and while playing back, no data is acquired.

The purpose of the data acquisition program is to collect sensor data and store it on tape. A limited facility for viewing data as it is collected is also provided. The program is designed to be run by non-computer oriented personnel with a minimum of training. Extensive (helpful printout) is available to the operator.

The playback program provides a limited capability for reviewing data recorded by the data acquisition program. It is intended for use mainly during calibration and trial periods, and requires greater skill of the user.

2. Data Acquisition Program

The data acquisition program is designed to:

1) collect sensor data and store it on tape;

2) permit limited viewing of the data via hardcopy printout while it is being collected by:

   a) monitoring a single sensor

   b) logging one value for every sensor

Once data gathering is started, the sampling of sensors is continuous. However the recording of data to tape is optional. Continuous recording mode may be selected, whereby all data collected is written to tape.

This may be useful for calibration and testing, but in general will record masses of uninteresting data. Consequently, a standby option has been provided. In the standby mode, any or all sensors may be assigned "alarm limits" to distinguish interesting values from uninteresting ones. As long as no sensor exceeds its alarm limits, no data is recorded on tape, although the sensors are sampled continuously. When any sensor exceeds its alarm limit, recording is started and continues for a pre-selected interval (30 seconds, for example), after which the program reverts again to standby, sampling but not recording. In standby mode, one second's worth of data is recorded to tape every hour, to provide static load and other information.

Until the operator halts data gathering, the sampling and recording of data takes precedence over other functions. Nevertheless, it is possible to verify operation of the system via two printout options which operate concurrently with data gathering:

(a) Monitoring

Any sensors may be selected for continuous printout and a value is typed periodically at a rate dependent on printer speed limitations. This is useful for checking a sensor which may be expected to vary over a period of seconds. It is not capable of reflecting changes occuring at faster rates due to printer speed limitations.

(b) Logging

In the absence of monitoring, logging printout is typed. One value for every sensor is typed at an interval selected by the operator (every 2 hours, for example). This is useful as a permanent record that the system was working, and also as a check on the proper functioning of the sensors. All values exceeding their alarm limits are flagged on the printout and a careful check should be made of readings on sensors that are not alarmed to ensure that they are reasonable.

Sampling pattern selection:

The sampling pattern must be selected before data gathering begins (see Section 3, para. 4). When the program is loaded or initialized, all sensors are set to be sampled once per second in peak holding mode. For any sensor, the rate and mode may be left at this default setting, or the rate and/or mode may be changed to any of the available options, or the sensor may be dropped from the sampling pattern (never sampled). The available sampling rates are:

1) Once in 10 seconds

2) Once per second, i.e. 1/sec.

3) 10/sec.

4) 40/sec.

5) 100/sec.

6) 250/sec.

7) 1,000/sec.

The sampling modes are:

R = Real (instantaneous)

P = Peak holding

3. Playback Program

The playback program provides a limited capability for reviewing data recorded by the data acquisition program. The tape may be searched by alarm limits or by date and time, to locate an area of interest. When the area of interest is located, the operator may proceed in one of three modes:

1) Monitoring mode prints all values or every Nth value (N selected by the operator) of one selected sensor. Statistics are also accumulated.

2) Dump mode prints every value recorded. This mode will be used only for debugging and system verification, since it takes up to an hour to print one second's worth of data. Statistics are also accumulated.

3) Statistics mode: No printout occurs as the tape is read. Statistics are accumulated.

Reading may be terminated in three ways:

1) By reaching a pre-selected end date and time,

2) By coming to the end of data on the tape, or

3) By the operator typing the ESC key.

The statistics routine is then entered, which provides the opportunity for typing the accumulated statistics on any or all sensors.

4. System Operation

Operation of the data acquisition system is mainly a matter of proper set up and initialization. When this has been done, the data obtained should be examined for gross errors, such as over or under range, and if required, can be checked against ship systems instrumentation. Verification is restricted to monitoring a chosen sensor or data logging.

The data logging function permits a quick scan of representative outputs from each sensor within the sampling pattern. Alarm indications (an asterisk after the logged value) would require further investigation. When selected, monitoring replaces data

logging, but when monitoring is terminated the system automatically reverts to data logging. A warning indication is printed to alert the operator to the dangers of completely disabling the logging function.

Notwithstanding gross checks on the operating system, the accuracy of the data acquisition hardware requires periodic checks by simulation of sensors at the junction box inputs.

Simulation is conducted by removing the channel amplifier card, which is then mounted on a special extension card and reinserted. This isolates the amplifier from the sensor excitation (where applicable) and sensor output. It also provides connections to a special test box. The test box provides a stabilized voltage which can be adjusted to simulate the normal output range of any particular sensor. Actual sensor outputs can thus be compared with simulated outputs appropriate to their calibration records.

5. Octal Representation

Inputs required by the computer system front panel switches are in Octal form, and entry in decimal form will either be rejected or will cause malfunction of the program.

Familiarity with Octal representation is essential for accurate operation of the data gathering system. (See Appendix A).

SECTION 2

SYSTEM OPERATION

SECTION 2 - SYSTEM OPERATION

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SECTION 2 - SYSTEM OPERATION

1. Computer Configuration

The control panel for the ROLM Model 1603A computer permits the operator to control and monitor system operation. Data may be entered manually into memory and the contents displayed. Similarly, data may be deposited into the processor registers and the contents examined. Figure 1 shows the arrangement of the controls and indicators on the panel.

The control panel has four display groups. At the upper right are four lights that indicate what is occuring within the processor. At the upper left are three status indicators which display the contents of the associated processor status flag. These indicators with their functions are listed in Table 1.

In the center of the control panel are two 16-bit binary LED displays. At the top is the ADDRESS, which may display either all memory reference addresses or instruction fetches only. Below is the DATA display.

Below the LED displays are sixteen toggle switches (0-15) through which the operator can supply addresses and data to the processor. These switches can be used in conjunction with certain operating switches and their binary content can be transferred under program control to an accumulator. The up positions of these switches represent binary 1 and the down positions represent binary 0.

Operating switches are located in the bottom row on the panel. Functionally, each toggle operates two momentary-contact logical switches with a common center-off position. Momentarily raising a toggle selects the function printed above the switch; depressing the switch selects the function printed below the switch. The functions of these switches are listed in Table 2.

All of the switches in the bottom row except STOP AND RESET are interlocked so that they have no effect if RUN is lighted. The four switches at the left are for depositing data in the accumulators and examining their contents. Lifting a switch lever up loads the contents of the DATA switches into the specified accumulator; pressing it down displays the contents of the accumulator in the DATA lights.

None of the switches in the bottom row have any effect if the front panel is disabled (PANEL ENABLE/DISABLE in the DISABLE position). The front panel should be disabled whenever a program is running.

2. Functional Summary

Certain basic functions may be selected by switches on the control panel. These functions with operating procedures and switch references are listed in Table 3.

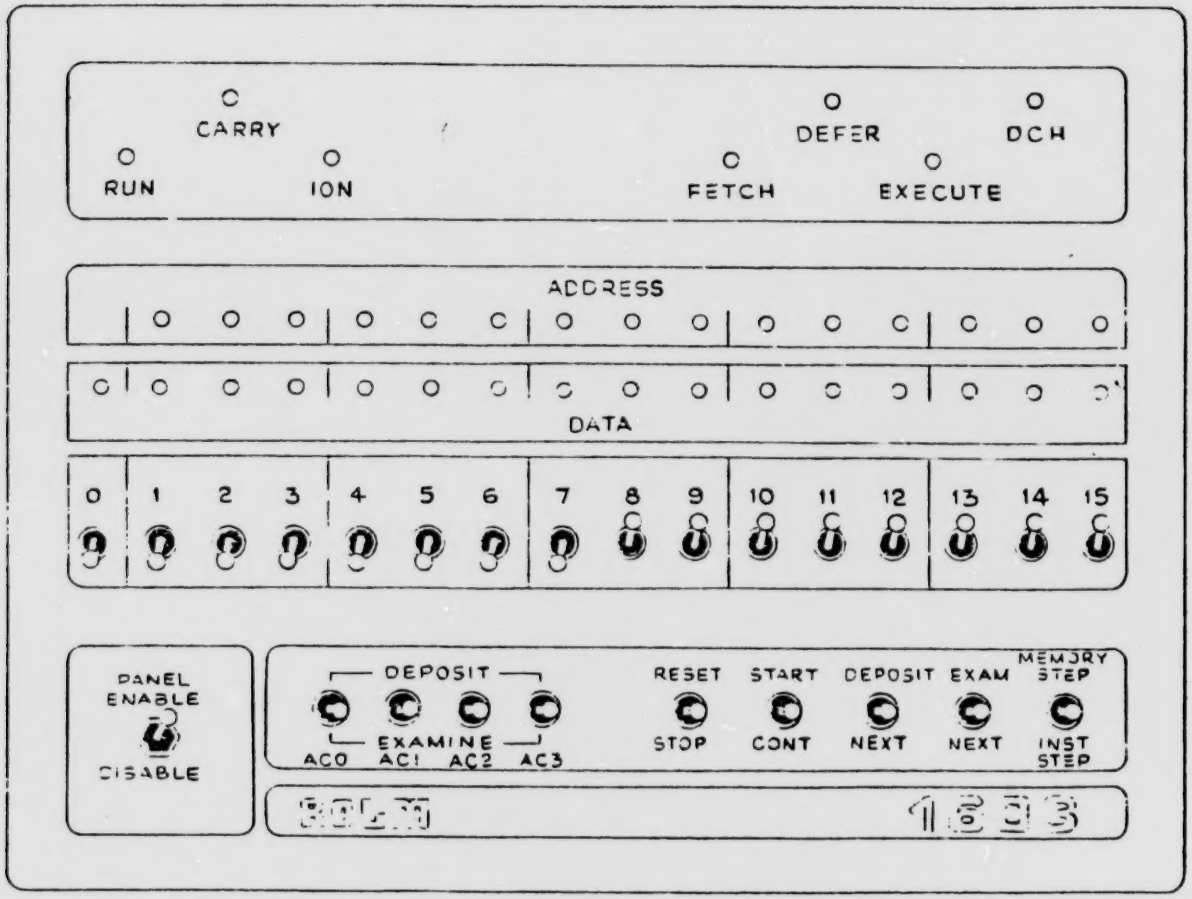


FIGURE 1 - ROLM 1603A COMPUTER INTEGRAL CONTROL PANEL

Table 1. Operation Indications

Indicator	Function
FETCH	When lit, it indicates that the next operation will be to fetch an instruction from memory.
DEFER	When lit, it indicates that the next processor operation will fetch an address word in an indirectly addressed memory reference instruction.
EXECUTE	When lit, it indicates that the next processor operation will reference memory for an operand in a memory reference instruction. EXECUTE is also used to indicate that an interrupt cycle is the next processor cycle.
DCH	When lit, it indicates that an I/O interface is requesting a direct memory access cycle. This indication is equivalent to the Data Channel Request signal from the I/O-Bus.
RUN	When lit, it indicates that the processor is in normal operation with the execution of one instruction following another. When not lit, it indicates that the processor is stopped.
CARRY	Displays the state of the Carry flag. When lit, it indicates that Carry is set.
ION	When lit, it indicates that program interrupt is enabled. (This is the Interrupt On flag.)

Table 2. Switch Operation

Switch	Function/Operation
EXAMINE (ACn)	When operated in the downward direction, displays the contents of the specified accumulator in the DATA lights. At completion, FETCH is lit and the ADDRESS lights display PC.
DEPOSIT (ACn)	When operated in the upward direction, deposits the contents of the DATA switches in the associated accumulator. At completion, FETCH is lit and the DATA lights display the contents of the DATA switches. The ADDRESS lights display PC.
RESET	When operated upward, processor operation stops at the end of the current memory cycle. An I/O reset pulse (IORST) is sent out to clear the flags in all I/O devices. The ION flag is cleared. FETCH is lit.
STOP	When depressed, the processor stops with FETCH on before beginning the next instruction. Thus, the processor finishes the current instruction and then stops unless a device is waiting for a program interrupt, in which case it performs all such operations before stopping. The ADDRESS lights point to the next instruction.
START	When operated in the upward direction, the address contained in the DATA switches is loaded into PC, FETCH and RUN are set, and normal operation begins with the executing of the instruction at the location specified by PC.
CONT	When this switch is depressed the processor turns on RUN and begins normal operation in the state indicated by the display.
DEPOSIT	When this switch is raised, the processor deposits the contents of the switches into the memory location specified by the ADDRESS lights. At completion, FETCH is lit and the DATA lights display the word deposited.
NEXT (DEPOSIT)	When this switch is depressed, the processor adds 1 to the PC address displayed by the ADDRESS lights and deposits the contents of the switches into the memory location specified by the incremented address. At completion, FETCH is lit and the indicators display the word deposited.
EXAM	When this switch is raised the processor loads the address contained in the switches into PC (which is displayed in the ADDRESS lights) and displays the contents of the address location in the DATA lights. At completion, FETCH is lit. NOTE: EXAM can also be used to load (PC) for beginning any single-step procedure. To use the various EXAM and DEP switches between instruction steps, simply recall what (PC) was and restore it before continuing.

Table 2. Switch Operation (Continued)

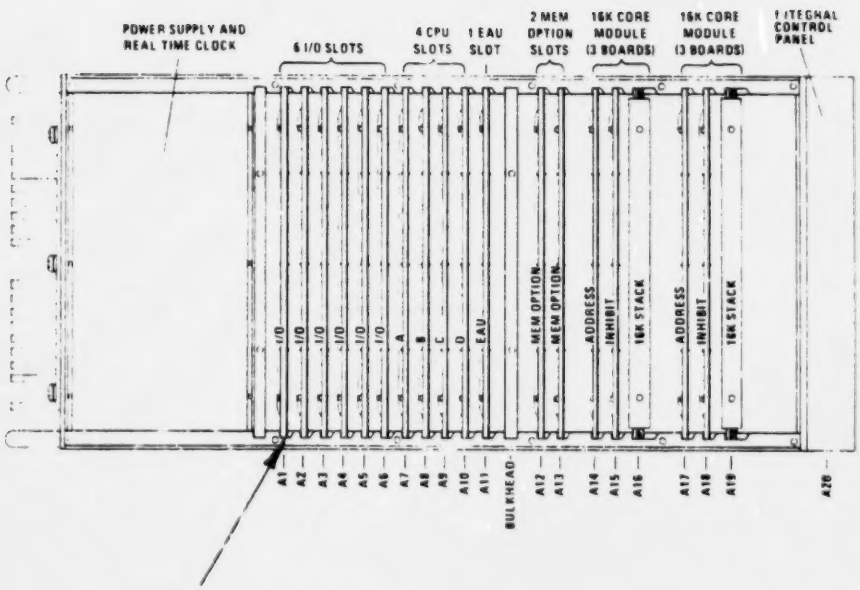
Switch	Function/Operation
NEXT (EXAM)	When this switch is depressed, the processor adds 1 to the (PC) address displayed by the ADDRESS lights, and displays the contents of the location specified by the incremented address in the DATA lights. At completion, FETCH is lit.
MEMORY STEP	For most instructions the MEMORY STEP switch causes the processor to perform a single processor cycle in the state indicated by the Status Indicators; the processor then stops. Raising this switch may cause certain instructions to stop in the Execute state. The instructions thus affected are JMP (indirect), JSR (indirect), LDA, STA, ISZ, and DSZ. When the processor stops in the Execute state, the ADDRESS lights display the next memory address to be accessed (bit 0 will be 1 if Multi-Level Indirect Addressing is taking place). When the MEMORY STEP switch is raised, the ADDRESS lights display each address sent to memory by the processor. The ADDRESS display displays all memory addresses until the START switch is raised.
INST STEP	When this switch is depressed, the processor begins operation in the state indicated by the display lights. It finishes one instruction, then stops.

Table 3. Basic Operating Functions

Selected Operation	Procedure
To run a program:	Put starting address in switches, and raise START.
To stop an executing program:	Depress STOP. If STOP fails to halt the processor, then the processor may be in a state that does not allow normal halts; in this case raise RESET.
To clear the I/O devices and reset the CPU to a standard state:	Raise RESET.
To continue the execution of a program from a stopping point:	Depress CONT.
To examine the contents of an accumulator:	Depress the appropriate EXAMINE AC switch. The contents will be displayed in the DATA display.
To deposit data into an accumulator:	Place the data in the switches. Raise the appropriate DEPOSIT AC switch.

Table 3. Basic Operating Functions (Continued)

Selected Operation	Procedure
To examine the contents of a memory location:	Place the memory address in the switches. Raise EXAM. The address will be displayed by the ADDRESS indicators and the contents of the memory location will be displayed by the DATA indicators.
To deposit data into an alterable memory location:	Place the memory address in the switches, and raise EXAM. (If the appropriate address already appears in the ADDRESS display, the above steps may be omitted.) Place the information to be deposited in the switches and raise DEP.
To examine a block of memory:	Place the starting address of the block in the switches and select EXAM. The address of the first word of the block will appear in the ADDRESS display and its contents will appear in the DATA display. Then repeatedly depress EXAM NEXT to increment the address. At all times the contents of the word addressed by the ADDRESS display will be indicated by the DATA display.
To deposit data into a block of memory:	Place the starting address of the block in the switches and raise EXAM. Place the first data word in the switches and press DEP. For subsequent data words, place them in the switches and depress DEP NEXT.
To cause the CPU to execute one program instruction from memory:	If necessary, use EXAM to get the address of the instruction into the ADDRESS display. Depress INST STEP.
To supply power: (Remote Panel)	Turn the power switch to ON.
To cut off power: (Remote Panel)	Turn the power switch to OFF.
To disable the STOP and RESET switches: (Remote Panel)	Turn the power switch to LOCK.
To disable the STOP and RESET switches: (Local Panel)	Place the PANEL ENABLE/DISABLE switch to the DISABLED position.



Location for 16 Bit Parallel Interface Board

FIGURE 2 - MODEL 1603A CONFIGURATION

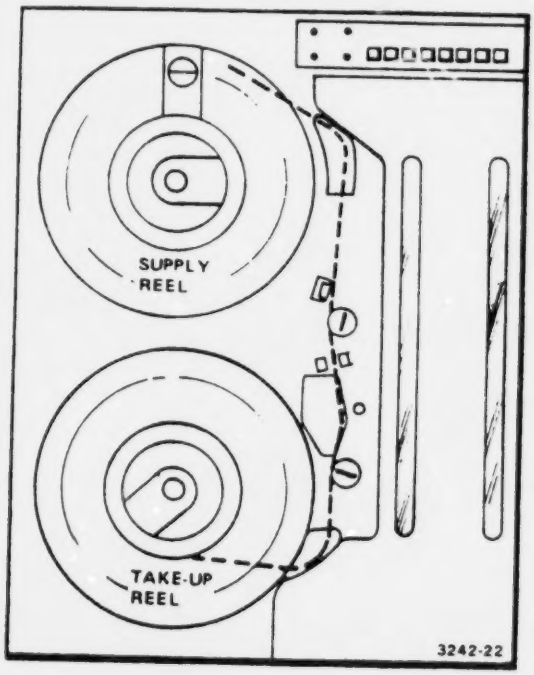


FIGURE 3 - TAPE THREADING PATH FOR MANUAL LOADING TRANSPORT

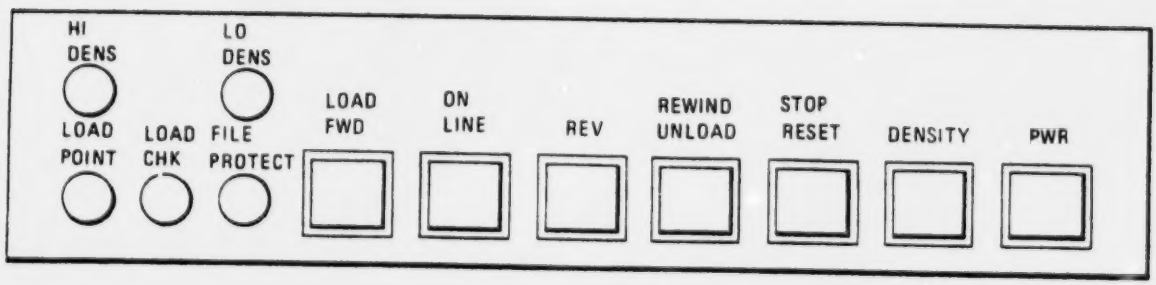


FIGURE 4 - OPERATOR CONTROL PANEL

3. Switch-On Procedure

The operation of the data acquisition system does not depend upon an input from each and every sensor, although this lack may limit the usefulness of the overall statistical data obtained. However, when setting up a sampling pattern the operator must recognize which channel numbers are not active and thus avoid the inclusion of meaningless and confusing data in the recordings.

The switching on procedure may leave one or a group of sensors inactive. This condition will be reflected in the sampling pattern.

Due to the numbers and locations of the sensing devices involved, some of them must be powered up at their local positions. These items are as follows:

a) Boxes 1 to 7, which contain the signal conditioning circuits.

b) A number of peripheral devices which provide discreet inputs to the system.

Shaft torque meter
Thrust meter
Anemometer
Doppler Log
Gyro compass
Pitch and Roll Gyro
Engine Tachometer
Shaft Tachometer

c) The computer and its peripherals.

d) The closed circuit television system.

Start-up procedures are as follows:

3.1 Junction Boxes

The main junction boxes, which contain the signal conditioning and addressing facilities for each sensor, are located as follows:

Boxes 1 to 4 are located in the forecastle, starboard side.

Box 5 is located in the Bubbler compartment.

Box 6 is located in the machinery flat on the starboard side.

Box 7 is located in the console against the forward part of the navigating bridge.

All boxes contain their own power supplies and must be individually powered up. This is done by ensuring that each box is plugged into the 115V AC convenience outlet, and then switched on by the key operated switch located at the top back corner. A red indicator light will confirm power on.

3.2 Individually Powered Sensors

Certain sensors are powered individually or require inputs from ship's equipment to provide data to the computer system. This applies to the following channels:

Box 6 - Channel 198 - Engine Thrust

To provide input to this channel, the RENK Checker must be switched on. This unit is located in the machinery flat, starboard side. The system is switched on by pressing S-1 power switch, a white control lamp lighting to confirm operation.

Box 7 - Channels 233 & 234 - Wind Speed & Direction

To obtain information on these channels, the anemometer must be operating, and with power on the Synchro to Analog convertor.

Box 7 - Channel 236 - Ship's Speed

To obtain this information the Doppler Log equipment must be operating, and with power on the Digital to Analog convertor.

Box 7 - Channels 237 & 238 - Ship's Heading

To obtain input to these channels the ship's #2 Gyro Compass must be operating. It is to be noted that no input is made to the system from Gyro Compass #1.

Box 7 - Channels 239 & 240 - Pitch and Roll

The Pitch/Roll Gyro must be running to provide meaningful information to the system. It is located in the laboratory.

Start-up procedure:

1) Switch on inverter. Allow to warm up till meter shows steadily 115v. output - adjust if necessary.

2) Switch on output. Gyro rotor will start running. Allow approximately 2 minutes to come up to speed.

3) Switch "Cage - Uncage" switch to "Uncage". Wait for completion of audible uncaging - approximately 10 - 15 seconds.

4) Switch "Erection" voltage "ON". Gyro is now operating.

Box 7 - Channels 241 & 242 - Engine and Shaft Tachometer

Equipment must be powered up.

Box 6 - Channels 194 & 195 - Shaft Torque

To activate the torquemeter, ensure that the base unit is plugged in to its adjacent 115V AC outlet. This unit is located immediately forward of the propeller pitch control, just above the main shaft. The readout on top of the base unit lights up when power is on.

3.3 Computer System

The computer system consists of the following units all located in the laboratory area:

Computer

Main Interface

Terminal

Tape Drives #0 and #1

Floppy Disc

Before applying power to the computer system check the following items:

Cables for interconnection are in accordance with the schematic shown in Drawing No. 3501-101 (Sheet 4)

16 bit I/O board is in position in computer frame (and not the floppy disc interface board). See Figure 2.

I/O connection from computer to main interface W4, and not to floppy disc drive.

On rear of tape drive unit 0, the selector switch is set to 0.

On rear of tape drive unit 1, the selector switch is set to 1.

Power to all units of the system is controlled from the key switch located at the top after side of the main computer rack.

Turning this switch "ON" will immediately activate the computer and main interface. The terminal, tape drives, and floppy disc are controlled from their individual power switches, once the key switch is "ON".

3.4 Closed Circuit Television System

For Normal Operation:

a) Set the key switch on the computer rack to the ON position.

b) Select MANUAL on the AUTO/MANUAL switch on the CCTV control panel

c) Select ON on the ON/OFF switch on the CCTV control panel

d) Select ON on the ON/OFF switch on the VTR

3.4 Closed Circuit Television System (Cont'd)

e) Turn ON monitors on the respective monitor control panels, including the navigating bridge monitor, if required, After a short period for warm-up, control of the camera and displays will be possible.

For Automatic Operation:

a) Start-up system as for Normal Operation above.

b) Set VTR to RECORD and select desired tape speed

c) Select AUTO on the AUTO/MANUAL switch on the CCTV control panel

d) Select OFF on the ON/OFF switch on the CCTV control panel

The camera will go to a pre-set position for scanning and the system will start-up automatically when Alarm A is activated.

Note: It is assumed that the Time/Date Generator is on. Otherwise it will have to be turned on and set.

4. Program Availability

Two programs are available to the system, Data Acquisition for normal data gathering and tests, and the Playback Program for analysis of the recorded data.

Either one of these two programs, dependent on operational mode desired, must be loaded into the computer memory to make the system operational.

To load either program the procedures outlined below will be used. Refers to Figure 3 and 4 and/or equipment panels.

5. Tape Loading Procedure

1) Open the tape deck door

2) Unlatch the supply reel hub, identified in Figure 3.

3) Place the supply reel on the supply reel hub, with write enable ring groove facing toward the transport and tape hanging free to the right.

4) Hold the supply reel firmly against the turntable surface; lock the hub latch.

5) Unwind approximately two feet of tape from the supply reel.

6) Thread the tape through the tape path as illustrated in Figure 3.

7) Wrap the tape leader around the take-up reel, then manually turn the take-up reel clockwise to wind at least 3 layers of tape unto the reel.

8) Depress the PWR pushbutton; verify that tape is driven forward and loaded in the vacuum chambers. Tape comes to rest with trailing edge to the BOT reflective tab positioned under photo-sense head. (LOAD POINT light illuminated.)

9) Determine that the LOAD POINT indicator illuminates when tape motion ceases. The system is now in standby status with the tape stopped at the load point.

10) Upon successful completion of the loading cycle, close the tape deck door.

CAUTION: Avoid closing the deck door while hub latch is released.

11) Depress the ON LINE pushbutton and verify status of the OPERATOR CONTROL PANEL (OCP).

PWR	ON
ON LINE	ON
HI DENS	ON
LOAD POINT	ON
LOAD CHK	OFF
FILE PROTECT	ON or OFF depending on whether a program tape or empty tape for data recording is loaded.
LO DENS	OFF

6. PROGRAM LOADING PROCEDURE

6.1 Loading from Tape

A two word bootstrap program is required to load the tape program into the computer and is inserted via the front panel switches on the computer as follows:

ACTION	COMMENT
Verify that the computer is on.	
Set ENABLE/DISABLE to ENABLE	Switches now active
Raise RESET (momentary)	RUN light out
Set switches to 000376	In octal
Raise EXAMINE (momentary)	000376 appears in address row of LEDs
Set switches to 60122	In octal
Raise DEPOSIT (momentary)	060122 appears in data row of LEDs. 060122 has now been loaded into location 376.
Set switches to 000377	In octal
Depress DEPOSIT NEXT (momentary)	000377 appears in both address and data rows. 000377 has now been loaded into location 377.
Verify that terminal is ON & ON LINE	
Set switches to 000376	In octal
Raise RESET (momentary)	
Raise START (momentary)	A short segment of tape is read into the computer.

NOTE: In order to distinguish between general comment, command/settings and print-out on the console, the latter will be shown in script. Underlining indicates characters previously printed on the same line.

FROM MTO: Will be typed at the terminal.

Respond by typing file number of desired program, followed by a carriage return (CR). The file number can be determined from the label on the program tape reel. The Data Acquisition Program is MVSV and the Playback Program is PBSV. Thus, if the tape label reads:

0 TBOOT
1 MV.SV
2 PB.SV,

Type 1 to load the Data Acquisition Program or 2 to load the Playback Program.

FROM MTO: 1

The program starts into its opening mode.

RTOS REV 4.00

** * * WELCOME TO THE M.V. ARCTIC DATA GATHERING SYSTEM * * **

TYPE "H" FOLLOWED BY THE "RETURN" KEY FOR HELPFUL PRINTOUT.

TYPE JUST "RETURN" FOR MINIMAL PROMPTING:

The program tape must now be dismounted before proceeding.

a) Press STOP/RESET switch on tape drive.

b) Press REWIND/UNLOAD switch.

c) Wait for LOAD POINT light.

d) Press REWIND/UNLOAD switch again.

e) When motion stops remove tape reel and store carefully.

Close hub latch and then transport door.

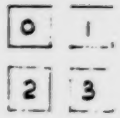
Note: The ROLM 1603A computer has a core memory which retains information after removal of power. It will not normally be necessary to reload the program unless:

a) A change has been made via front panel switches or interactive debugger.

b) A new program such as data playback has been loaded.

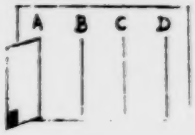
6.2 Loading from Floppy Disc

1) Power off computer, floppy disc.
Remove interface cable from A1J3.
Connect floppy cable to A1J3.
Remove 16-bit parallel interface from computer.
Insert floppy interface.
Power on to computer.
Thumbwheels on front of floppy should read



Power on to floppy

2) Load floppy labelled "#5 - Test Routines" into Unit A with label in bottom right corner



Close door.

3) On computer, set switches to 000377

Life RESET
EXAMINE
DEPOSIT
START

4) On floppy, depress IPL switch

- Result: *FILENAME?* typed on console.

5) Type *MV/A (CR)*

Result: Halt w/ 63077 in bottom row of lights, RUN light out.

REMOVE FLOPPY.

6) Power off computer, floppy disc.

Replace 16-bit parallel interface card
Swap cables
Power on computer
Follow run instructions from section for data gathering program or for test modes.

SECTION 3

DATA ACQUISITION INITIALIZATION

SECTION 3 DATA ACQUISITION INITILIZATION

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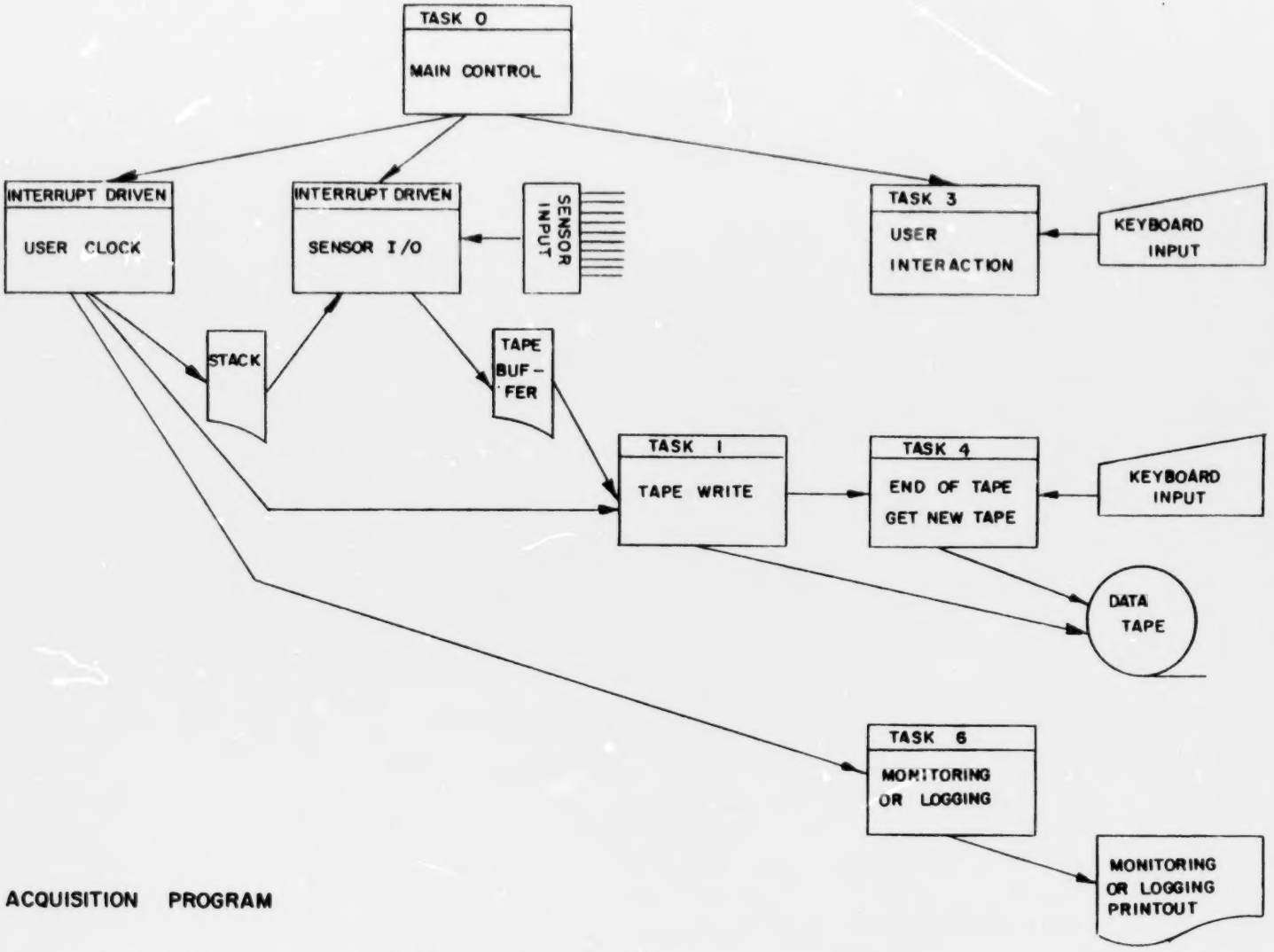

ACQUISITION PROGRAM

SECTION 3 - DATA ACQUISITION INITIALIZATION

1 General Format of Initialization

The general format of the data acquisition system initialization is as follows:

a) Selection of "HELPFUL" or "MINIMAL PROMPTING" mode

b) Date and Time entry

c) Sampling pattern selection

d) Alarm limit selection

e) Logging interval selection

f) Monitoring interval selection (including Alarm B.)

g) Recording mode selection

h) Tape unit selection

i) Examination or modifications (repeat of any section a-h)

2 Prompting

Upon a successful program load the terminal printout will be as follows:

FROM MTO: 1

FROM REV. 4.00

** * * WELCOME TO THE MV ARCTIC DATA GATHERING SYSTEM * * **

TYPE "H" FOLLOWED BY THE "RETURN" KEY FOR HELPFUL PRINTOUT.

TYPE JUST THE "RETURN" FOR MINIMAL PROMPTING:

The data acquisition program provides two types of prompting:

a) A "HELPFUL" mode wherein much prompting and explanation is provided for the inexperienced operator.

b) A "MINIMAL PROMPTING" mode for quick setup and modification by an experienced operator.

The following sections will be explained by use of the "HELPFUL" mode, with an example showing "MINIMAL PROMPTING" at the end of each section. Type H to select "HELPFUL" printout.

.....MINIMAL PROMPTING: H

The following printout of general instructions occurs when "HELPFUL" printout is requested. If "HELPFUL" printout is not requested, date and time selection (Paragraph 3) starts immediately.

SYSTEM STARTUP REQUIRES OPERATOR SELECTION OF VARIOUS OPTIONS AND PARAMETERS.

**A PROMPT CHARACTER (: OR ?) APPEARS WHEN THE COMPUTER IS WAITING FOR INPUT FROM THE OPERATOR.*

**ONLY A SINGLE LETTER IS REQUIRED TO SELECT AN OPTION. FOR EXAMPLE, H WAS TYPED TO SELECT HELPFUL PRINTOUT.*

**EVERY RESPONSE TYPED MUST BE FOLLOWED BY THE "RETURN" KEY (ABBREVIATED "CR").*

TYPE JUST "CR" TO PROCEED TO THE NEXT SECTION.

NO COMPUTER ACTION IS TAKEN UNTIL "CR" IS TYPED. THEREFORE, A TYPING ERROR MAY BE CORRECTED (AS DESCRIBED BELOW) AT ANY TIME BEFORE "CR" IS TYPED. AFTER "CR" IS TYPED, THE COMPUTER MUST RESPOND BEFORE FURTHER ENTRIES CAN BE MADE.

BEFORE "CR" IS TYPED, CORRECTION MAY BE ACCOMPLISHED IN TWO WAYS: BY DELETING THE LINE AND STARTING AGAIN OR BY BACKSPACING ONE CHARACTER AT A TIME AND RE-ENTERING FROM THE ERROR.

**TO DELETE A WHOLE LINE, TYPE THE BACKWARDS SLASH KEY (SHIFT "L"). THE BACK SLASH IS PRINTED AND A "C" DONE AUTOMATICALLY. START TYPING AT THE BEGINNING OF THE LINE.*

**TO DELETE A FEW CHARACTERS, USE THE "RUBOUT" KEY. EACH TIME "RUBOUT" IS TYPED, ONE CHARACTER IS DELETED FROM THE END OF THE LINE. WHEN ALL ERRONEOUS CHARACTERS HAVE BEEN DELETED, START TYPING FROM THAT POINT.*

3 Date & Time

Proper date and time information is essential in the data acquisition system and must always agree (within 2 seconds) with the date and time information shown on the video monitor. This permits "synchronization" of the video system to the data system. Normally the video date and time generator should be clocked daily against a known time standard (WWV, CHU, etc.) with the aid of the radio operator. Loss of AC power or program change (to data playback) will require resetting of the internal computer clock. Power down will not affect the video date time generator which is powered from the 24V DC supply.

Entry for date and time information is well explained by the printout but the operator must be careful to use commas for the delineators. Information pertaining to seconds should be typed in with a value of at least 15 seconds in advance of the actual time. When the video monitor indicates the time as typed, the "RETURN" key should be depressed to enter the time into the computer.

** * * DATE & TIME * * **

ENTER THE DATE WITH YEAR FIRST. YEAR SHOULD BE TWO DIGITS; MONTH AND DAY MAY BE ONE OR TWO DIGITS. ENTER THE TIME USING A 24-HOUR CLOCK. HOURS AND MINUTES MUST BE ENTERED; SECONDS WILL BE SET TO ZERO IF OMITTED. THE TIME IS SET WHEN "CR" IS TYPED. OR, TYPE JUST "CR" TO LEAVE THE DATE OR TIME INTACT.

DATE (Y,M,D):	CR	Request for entry
DATE (Y,M,D):78,8,12	(CR)	Enter new values then "CR"
TIME (H M S):		Request for entry
TIME (H M S): 1,14,30	(CR)	Enter new values, then wait for proper seconds to appear on the video monitor. Then type "CR".
78Y 08M 12D 01H 14M 30S		Terminal types values as entered

After printout of the date & time setting, the terminal will proceed to the sampling pattern selection.

4 Sampling Pattern Selection

The sampling pattern must be selected before data gathering begins. When the program is loaded or initialized, all sensors are set to be sampled once per second in peak holding mode. For any sensor, the rate and mode may be left at this default setting or the rate and/or mode may be changed to any of the available options, or the sensor may be dropped from the sampling patterns (never sampled).

** * * SAMPLING PATTERN * * **

THE SAMPLING PATTERN SPECIFIES WHICH SENSORS ARE SAMPLED, AT WHAT RATES, AND IN WHICH MODES.

** INITIALIZE SETS ALL SENSORS TO DEFAULT SAMPLING (RATE 2, PEAK MODE), BUT DOES NOT AFFECT THE EXISTING ALARM LIMITS. SENSOR SETTINGS MAY BE EXAMINED OR MODIFIED.*

** MODIFY LEAVES THE EXISTING SAMPLING PATTERN AND ALARM LIMITS INTACT. SENSOR SETTINGS MAY BE EXAMINED OR MODIFIED.*

** CHECK LEAVES THE EXISTING SAMPLING PATTERN AND ALARM LIMITS INTACT. SENSOR SETTINGS MAY BE EXAMINED, BUT NOT MODIFIED. REMEMBER TO TYPE "CR" AFTER EVERY RESPONSE.*

** TYPE JUST "CR" TO PROCEED TO THE NEXT SECTION.*

INITIALIZE, MODIFY OR CHECK:

4.1 Initialize:

Type the response 1 followed by a "CR"
When the initialize option is selected, an additional check is made to ensure that the operator really wishes to destroy the existing pattern. If so, type C followed by "CR"; if not, type just "CR" and the INITIALIZE, MODIFY, OR CHECK: question will be asked again.

INITIALIZE, MODIFY OR CHECK: I

CONTINUING DESTROYS THE SAMPLING PATTER, TYPE C TO CONTINUE: C

Once the pattern is initialized, the program proceeds with the modify option.

4.2 Modify:

Type the response M followed by a "CR"

INITIALIZE, MODIFY, OR CHECK: M

SENSOR ADDRESSES (ABBREVIATED ADR OR ADRS) MAY BE ENTERED:

1 SINGLY (ADR)

2 AS A RANGE (ADR1-ADR2)

3 AS A RANGE WITH AN INCREMENT (ADR1-ADR2/INCR).

WHENEVER "ADRS" IS CALLED FOR, ANY OF THESE 3 FORMATS MAY BE USED.
WHEN THE PROMPT INDICATES "ADR", A SINGLE ADR MUST BE ENTERED.
SAMPLING RATE IS A SINGLE DIGIT 0 to 7.

0	DO NOT SAMPLE THIS SENSOR.
1	ONCE EVERY 10 SECONDS.
2	ONCE PER SECOND.
3	10/SEC.
4	40/SEC.
5	100/SEC.
6	250/SEC.
7	1000/SEC.

DEFAULT IS RATE 2.

SAMPLING MODE IS A SINGLE LETTER, R OR P.

R	REAL MODE (INSTANTANEOUS VALUE).
P	PEAK MODE (HIGHEST VALUE SINCE LAST READ).

DEFAULT IS MODE P.

THE EXISTING SENSOR SETTINGS MAY BE EXAMINED BY TYPING ADRS"CR".
THE SAMPLING PATTERN IS ESTABLISHED BY TYPING ADRS,RATE,MODE"CR".
SOME EXAMPLES:

100	TYPES THE PRESENT STATUS OF ADR 100
100,0	REMOVES ADR 100 FROM THE SAMPLING PATTERN (RATE 0)
100,5,R	SETS ADR 100 TO RATE 5, REAL MODE
100-150,3,P	SETS ADR 100 THRU 150, INCLUSIVE, TO RATE 3, PEAK MODE
100-150,/3,0	REMOVES EVERY THIRD ADR FROM 100 THRU 150 FROM THE SAMPLING PATTERN (100,103,106...148)

THE MAXIMUM OVERALL SAMPLING RATE IS 2850 SAMPLES PER SECOND.
THIS MAY BE DIVIDED AMONG THE SENSORS IN ANY WAY BY THE OPERATOR. THE LIMIT OF 2850 MAY NOT BE EXCEEDED, BUT IS NOT NECESSARILY REACHED. FOR EXAMPLE, ALL 255 SENSORS COULD BE SAMPLED AT RATE 3 (10/SEC) FOR A TOTAL OF 2250 SAMPLES/SEC.

OR THE PATTERN COULD INCLUDE 180 SENSORS AT RATE 3, ONE SENSOR AT RATE 7, 20 SENSORS AT RATE 1, AND 54 SENSORS NOT SAMPLED (TOTAL 2802/SEC). THREE SAMPLES AT RATE 7 (TOTAL 3000 SAMPLES/SEC) IS NOT LEGAL. THE PROGRAM KEEPS TRACK OF THE TOTAL SAMPLES/SEC REQUESTED AND PRINTS THE UPDATED VALUE AFTER EACH CHANGE. IF A RATE IS REQUESTED WHICH WOULD EXCEED THE LIMIT, AN ERROR MESSAGE IS PRINTED AND THE SENSOR IN QUESTION REMAINS AT ITS OLD RATE.

ENTER ADRS OR ADRS,RATE,MODE:

2595 SAMPLES/SECOND TO GO

:

The operator then enters the various address, rates and modes required. After each entry the terminal types the number of samples left, or error messages if appropriate.

The user examines and/or modifies sensor rates and modes until the desired sampling pattern is achieved. He then types just "CR" in response to the : prompt, and proceeds to Alarm Limit Selection (Paragraph 5)

4.3 Check:

Type the response C followed by "CR". If the user wishes to check the sampling pattern without modifying any addresses (during data gathering, for instance) he selects check mode.

INITIALIZE, MODIFY OR CHECK: C

THE EXISTING SENSOR SETTINGS MAY BE EXAMINED BY TYPING ADRES"CR".

ENTER ADRS:

2595 SAMPLES/SECOND TO GO

:

Check mode differs from the initialize and modify modes in that an error message will be returned if the user attempts to modify any address.

4.4 Example of minimal prompting mode:

```
* * *SAMPLING PATTERN* * *
INITIALIZE,MODIFY, OR CHECK: M
ENTER ADRS OR ADRS,RATE,MODE:
2595 SAMPLES/SECOND TO GO
:1-2,7,R
0597 SAMPLES/SECOND TO GO
:3-4,6,R
0099 SAMPLES/SECOND TO GO
:5,5,R
0000 SAMPLES/SECOND TO GO
: 100-199,1,P
0090 SAMPLES/SECOND TO GO
: 6-7,4,R
0012 SAMPLES/SECOND TO GO
: 8,3,R
0003 SAMPLES/SECOND TO GO
:
```

Upon completion of the sampling pattern section, a "CR" causes the program to continue to the alarm limit section.
The text as printed by the terminal is self-explanatory.

5 Alarm Limits

NOTE: Alarm limits are specified as 0 to 1023, the decimal equivalent to the 10 bit binary range at the A D converter.

Refer to the conversion tables for engineering unit equivalents for alarm setting.

```
* * *ALARM LIMITS* * *
AN "ALARM CONDITION" EXISTS IF ANY SENSOR RETURNS A VALUE LESS
THAN ITS ASSIGNED MINIMUM OR GREATER THAN ITS ASSIGNED MAXIMUM.
DEFAULT LIMITS ARE 0 (MIN) AND 1023 (MAX) FOR ALL SENSORS.  WITH
THE DEFAULT LIMITS, NO ALARM CONDITION IS POSSIBLE.

"INITIALIZE SETS ALL SENSORS TO DEFAULT LIMITS (0 MIN, 1023 MAX),
 BUT DOES NOT AFFECT THE EXISTING RATE AND MODE.  ALARM LIMITS
 MAY BE EXAMINED OR MODIFIED.
```

**MODIFY LEAVES THE EXISTING ALARM LIMITS INTACT. ALARM LIMITS MAY BE EXAMINED OR MODIFIED.*

**CHECK LEAVES THE EXISTING ALARM LIMITS INTACT. SENSOR SETTINGS MAY BE EXAMINED, BUT NOT MODIFIED.*

INITIALIZE,MODIFY OR CHECK:

5.1 Initialize:

Type the response 1 followed by a "CR". When the initialize option is selected, an additional check is made to ensure that the operator really wishes to destroy the existing alarm limits. If so, type C followed by "CR". If not, type just "CR" and the INITIALIZE,MODIFY OR CHECK: question is repeated.

INITIALIZE,MODIFY, OR CHECK: I

CONTINUING DESTROYS EXISTING LIMITS, TYPE C TO CONTINUE: C

Once the alarm limits are initialized, the program proceeds with the modify option.

5.2 Modify:

Type the response M followed by a "CR"

INITIALIZE,MODIFY, OR CHECK: M

ALARM LIMITS ARE ASSIGNED BY TYPING:

ADRS,MIN,MAX"CR"	*TO SET BOTH MIN AND MAX*
ADRS,MIN,"CR"	*TO SET MIN AND LEAVE MAX INTACT*
ADRS,MAX"CR"	*TO SET MAX AND LEAVE MIN INTACT*

ADRS IS AS DESCRIBED IN THE SAMPLING PATTERN SECTION. THE MIN MUST BE LESS THAN OR EQUAL TO THE MAX. VALID SETTINGS ARE 0 TO 1023, INCLUSIVE.

ENTER ADRS OR ADRS,MIN,MAX:

:

The operator then enters various addresses and alarm limits required. Incompatible limits (min>max) and format errors are rejected.

When all desired alarm limits have been entered, the user types just "CR" in response to the : prompt, and proceeds to Logging Interval Selection (Paragraph 6)

5.3 Check:

Type the response C followed by "CR".
If the user wishes to check the alarm limits without modifying anything (during data gathering for instance), he selects check mode.

INITIALIZE,MODIFY, OR CHECK: C

THE EXISTING SENSOR SETTINGS MAY BE EXAMINED BY TYPING ADRS"CR".

ENTER ADRS:

:

Check mode differs from the initialize and modify modes in that an errror message will be printed if the user attempts to modify any alarm limits.

: 123,500,600

CHECK MODE REQUIRES ADRS ONLY

: 123

123,2,P

Example of minimal prompting mode

** * * ALARM LIMITS* * **

INITIALIZE, MODIFY OR CHECK: M

: 2-255,500,520

: 100,,0

MIN MAX

6 Logging Interval

A straightforward function described by the text but which is disabled when the monitoring function (Paragraph 7) is in use.

Note also that a 0 input for period will cause a warning message to be printed and an additional keyboard entry is required to enter a "NO LOGGING" condition.

A logging interval incompatible with the printout time involved will be rejected.

** * *LOGGING INTERVAL* * **

LOGGING CONSISTS OF PRINTING, AT A SPECIFIED TIME INTERVAL, ONE VALUE FOR EACH SENSOR IN THE SAMPLING PATTERN. THE TIME INVERVAL MAY BE SPECIFIED IN HOURS OR MINUTES. TYPE ONE OR TWO DIGITS, FOLLOWED BY "H" FOR HOURS OR "M" FOR MINUTES.

INTERVAL IS 01 HOURS.
NEW INTERVAL: Request

6.1 Logging disable:

NEW INTERVAL: 0

NO LOGGING MEANS FAILED SENSORS ARE NOT DETECTED, WHICH IS A DANGEROUS OPTION. TYPE C TO CONTINUE: C

If logging is truly not desired, type C and "CR" after the request. To enable logging, type just "CR" and continue with section 6.2

6.2 Logging enable, example with minimal prompting:

** * *LOGGING INTERVAL* * **	CR	Comment
INTERVAL IS 01 HOURS.		
NEW INTERVAL:		Request
NEW INTERVAL: 2	(CR)	New entry should be followed by M or H.
HOURS OR MINUTES:		Prompt by computer
HOURS OR MINUTES: M	(CR)	Response
VALUE ERROR		Value is less than printout time Rejected.
NEW INTERVAL:		Request
NEW INTERVAL: 10 M	(CR)	New value
INTERVAL IS 10 MINUTES		Terminal types acceptable value as entered.

7 Monitoring/Alarm B

7.1 Monitoring

As noted in Paragraph 6, monitoring replaces logging if selected. When monotoring is halted, the program returns to logging automatically unless logging has been separately disabled.

Attempted selection of an address not within the sampling patter selection of Paragraph 4 will be rejected.

** * *MONITORING* * **

MONITORING MAY REPLACE LOGGING. ONE SPECIFIED SENSOR IS PRINTED ABOUT ONCE EVERY TWO SECONDS. ENTER ZERO TO DISABLE MONITORING OR AN ADR TO MONITOR THAT SENSOR.

	CR	Comment
NO MONITORING		Present status
ADR:		Request for address
ADR:250	(CR)	Attempt to address sensor not in sampling pattern
ADR NOT SAMPLED		Rejected
ADR:		New request
ADR: 100	(CR)	New Address
MONITORING ADR 100		Confirmation

If monitoring is not desired, type just a "CR" when ADR: is requested.

7.2 Alarm B

A SELECTED SENSOR MAY ALSO BE CONNECTED TO ALARM "B", SO THE ALARM WILL LATCH IF THE ASSIGNED LIMITS ARE EXCEEDED. TYPE ZERO TO DISABLE THIS ALARM OR AN ADR TO CONNECT THAT SENSOR TO THE ALARM.

	CR	Comment
NO ALARM B.		Present status
ALARM B ADR:		Request for address
ALARM B ADR: 250	(CR)	Attempt to address sensor not in sampling pattern
ADR NOT SAMPLED		Rejected
ALARM B ADR:		Request for valid address
ALARM B ADR: 007	(CR)	New address
ALARM B ON ADDRESS 007		Confirmation

To disable alarm B, type 9 (Zero) and "CR" when ALARM B ADR: is requested.

7.3 Example of Minimal Prompting Mode:

** * *MONITORING* * **
NO MONITORING
ADR: 120
MONITORING ADR 120.
NO ALARM B.
ALARM B ADR: 121
ALARM B ON ADR 121.

8 Recording Mode

** * *RECORDING MODE* * **
RECORDING OR STANDBY MODE MAY BE SELECTED. IF RECORDING IS SELECTED, ALL VALUES SAMPLED ARE RECORDED ON TAPE; IF STANDBY IS SELECTED, SAMPLING CONTINUES NORMALLY BUT NO VALUES ARE RECORDED UNLESS AN ALARM CONDITION EXISTS. AN ALARM CONDITION TRIGGERS RECORDING FOR SOME NUMBER OF SECONDS, AFTER WHICH THE PROGRAM REVERTS TO STANDBY AGAIN. IF STANDBY MODE IS SELECTED, THE DURATION (IN SECONDS) OF RECORDING MAY ALSO BE SPECIFIED.

STANDBY, ALARM TRIGGERS RECORDING FOR 15 SECONDS.
SELECT RECORDING OR STANDBY: Request

SELECT RECORDING OR STANDBY: R	(CR)	User selects recording mode
RECORDING		Confirmation.

8.1 Minimal Prompting Mode

** * *RECORDING MODE* * **		
RECORDING.		Report present mode
SELECT RECORDING OR STANDBY:		Request for status
SELECT RECORDING OR STANDBY:S	(CR)	New status
NEW DURATION:		Request new time
NEW DURATION:20S	(CR)	New value (with error)
FORMAT ERROR		Rejected
NEW DURATION:		Request new time
NEW DURATION: 20	(CR)	New value
STANDBY, ALARM TRIGGERS RECORDING FOR 20 SECONDS		Confirmation

9 Tape Unit

This section of the program informs the computer which tape drive is initially selected for writing and whether an alternate drive is available:

** * *TAPE UNIT* * **	
MAG TAPE INITIAL SELECTION	
1 OR 2 UNITS:	Request for information
1 or 2 UNITS: 2 (CR)	Type in number of drives operational

MOUNT TAPE FOR WRITING, TYPE UNIT (0 or 1:	Request
MOUNT TAPE FOR WRITING, TYPE UNIT (0 or 1): 0(CR)	Answer
MOUNT TAPE FOR ALTERNATE, TYPE UNIT (0 OR 1):	Request
MOUNT TAPE FOR ALTERNATE, TYPE UNIT (0 OR 1): 1(CR)	Answer

9.1 Magnetic Tape Problems

Some problems may be encountered with the nagnetic tape drives and following points should be noted:

1. If the unit number is entered in response to:

TYPE UNIT NO. (0 or 1):

When the magnetic tape is not powered up, loaded, or on line, the program will hang up.

2. If a bad section of tape is encountered, the tape may rewind and underwrite itself.

Other problems may arise, where the tape seems to behave erratically. The general solution to this sort of problem is as follows:

1. Type the ESC key.
2. If asked, choose the HALT DATA GATHERING option.
3. In respnse to ? , type T to get the tape setup routine.
4. Mount a new tape (if applicable).
5. Resume data gathering by typing "CR" in response to ?.

10 End of Initialization

When the tape unit selection is completed, the program offers the opportunity to go back and check or modify any input, (Paragraphs 2 thru 9). The following example illustrates this feature.

IF EVERYTHING IS OK, TYPE C TO BEGIN DATA GATHERING. TO CHECK OR MODIFY ANYTHING, TYPE JUST "CR", AND WHEN THE "?" PROMPT APPEARS SELECT THE SECTION TO BE RE-RUN. READY, TYPE C TO CONTINUE:

WHEN THE "?" PROMPT APPEARS, INDICATE WHICH OPTION YOU WISH TO MODIFY OR CHECK BY TYPING THE CODE LETTER LISTED BELOW, FOLLOWED BY "CR". TYPE JUST "CR" WHEN YOU ARE DONE.

P	*TO GET MINIMAL PROMPTING*
H	*TO GET HELPFUL PRINTOUT*
D	*DATE & TIME*
S	*SAMPLING PATTERN*
A	*ALARM LIMITS*
L	*LOGGING*
M	*MONITORING & ALARM B*
R	*RECORDING MODE*
T	*TAPE UNIT SELECTION*

? P	(CR)	Select minimal prompting
? S	(CR)	Review sampling pattern selection
** * *SAMPLING PATTERN* * **		Notice absence of explanatory print-out
INITIALIZE,MODIFY,OR CHECK: M	*(CR)*	Modify option selected
ENTER ADRS OR ADRS,RATE, MODE:		
0003 SAMPLES/SECOND TO GO		
: 1-10	*(CR)*	Request status of addresse 1-10
001,7,R,0512,0520		
002,7,R,0512,0520		
003,6,R,0512,0520		
004,6,R,0512,0520		
005,5,R,0512,0520		
006,4,R,0512,0520		
007,4,R,0512,0520		
008,3,R,0512,0520		
009,2,P,0512,0520		
010,2,P,0512,0520		
:	*(CR)*	Type just "CR" to exit this section
?	(CR)	Type just "CR" to start data gathering

Or Data Gathering may be started immediately by responsing with C and "CR" to the READY, TYPE C TO CONTINUE : prompt.

11 Data Gathering

When data gathering starts, the following message is printed (in helpful prompting mode only)

TYPE THE "ESC" KEY TO EXAMINE OR MODIFY OPTIONS.

Data Gathering then proceeds, with the selected monitoring or logging printout appearing from time to time and with our without continuous recording, as selected in the Recording Mode section.

User intervention will be necessary from time to time to mount new tapes, but aside from this, the system will operate automatically for days.

When the user wishes to change any of the operating parameters of the system, he types the ESC Key.

ESC

is printed out.

12 Changing Data Gathering Options

When the operator wishes to change any of the operating parameters, he types the ESC Key

TYPE THE "ESC" KEY TO EXAMINE OR MODIFY OPTIONS.

ESC

THE SAMPLING PATTERN AND ALARM LIMITS MAY BE CHECKED AND ANY OTHER SYSTEM PARAMETERS MAY BE MODIFIED WITHOUT HALTING DATA GATHERING. HOWEVER, TO CHANGE THE SAMPLING PATTERN OR ALARM LIMITS, DATA GATERING MUST CEASE AND ALL DATA WILL BE LOST UNTIL CHANGES ARE COMPLETED.

HALT DATA GATHERING (Y OR N)?

Some data will be lost if the user elects to halt data gathering, so this should be done only when necessary to change the sampling pattern and alarm limits. An additional check is performed when the user asks to halt data gathering:

12.1 Halt Data Gathering

HALT DATA GATHERING (Y OR N) ? Y

CONTINUING HALTS DATA GATHERING, TYPE C TO CONTINUE: C

78Y 11M 29D 10H 51M 22S (the time is typed when D.G. is halted)

WHEN THE "?" PROMPT APPEARS, INDICATE WHICH OPTION YOU WISH TO MODIFY OR CHECK BY TYPING THE CODE LETTER LISTED BELOW, FOLLOWED BY "CR" WHEN YOU ARE DONE.

```
P       TO GET MINIMAL PROMPTING
H       TO GET HELPFUL PRINTOUT
D       DATE & TIME
S       SAMPLING PATTERN
A       ALARM LIMITS
L       LOGGING
M       MONITORING & ALARM B
R       RECORDING MODE
T       TAPE UNIT SELECTION

?
```

Normally, the user will immediately select P to get minimal prompting, then continue with his desired changes. The printout will appear exactly as for the initialization sections.

12.2 During Data Gathering

Note that when data gathering is not halted, the user is unable to change the sampling pattern or alarm limits. Example:

```
HALT DATA GATHERING (Y OR N) ? N

WHEN THE "?" PROMPT APPEARS, INDICATE WHICH OPTION YOU WISH TO
MODIFY OR CHECK BY TYPING THE CODE LETTER LISTED BELOW, FOLLOWED
BY "CR".  TYPE JUST "CR" WHEN YOU ARE DONE.

P       TO GET MINIMAL PROMPTING
H       TO GET HELPFUL PRINTOUT
D       DATE & TIME
S       SAMPLING PATTERN
A       ALARM LIMITS
L       LOGGING
M       MONITORING & ALARM B
R       RECORDING MODE
T       TAPE UNIT SELECTION
? S                                (CR)     Select sampling pattern
```

```
* * *SAMPLING PATTERN* * *
THE EXISTING SENSOR SETTINGS MAY BE EXAMINED BY TYPING ADRS"CR".
ENTER ADRS:
2595 SAMPLES/SECOND TO GO
: 1,R,7                                (CR)    Attempt to change setting
CHECK MODE REQUIRES ADRS ONLY                  Error
: 1,R,7                                (CR)    Try again error
CHECK MODE REQUIRES ADRS ONLY
: 1                                    (CR)    Ask for address 1 setting
001,2,P                                        Reported
:                                      (CR)    Return to option level

  P       TO GET MINIMAL PROMPTING
  H       TO GET HELPFUL PRINTOUT
  D       DATE & TIME
  S       SAMPLING PATTERN
  A       ALARM LIMITS
  L       LOGGING
  M       MONITORING & ALARM B
  R       RECORDING MODE
  T       TAPE UNIT SELECTION
  ? A                                  (CR)    Select alarm limits

* * *ALARM LIMITS* * *
THE EXISTING SENSOR SETTINGS MAY BE EXAMINED BY TYPING ADRS"CR".
ENTER ADRS:
: 1-3                                  (CR)    Examine sensors
001,2,P
002,2,P
003,2,P
:                                      (CR)    Return to option level
?                                      (CR)    Resume data gathering
```

12.3 Example with Minimal Prompting

```
ESC
HALT DATA GATHERING (Y OR N)? Y      (CR)
CONTINUING HALTS DATA GATHERING, TYPE C TO CONTINUE:          (CR)
HALT DATA GATHERING (Y OR N)? N      (CR)

SELECT OPTION D,S,A,L.M,R,T, OR HELP
? S                                  (CR)     Select sampling pattern
* * *SAMPLING PATTERN* * *
ENTER ADRS:
2595 SAMPLES/SECOND TO GO
: 1-3                                (CR)     Examine sensors 1-3
001,2,P
002,2,P
004,2,P
:                                    (CR)     Return to option level
? A                                  (CR)     Select alarm limits

* * *ALARM LIMITS* * *
ENTER ADRS:
: 1-3                                (CR)     Examine sensors 1-3
001,2,P
002,2,P
003,2,P                              (CR)     Return to option level
:
?                                    (CR)     End of user intervention
```

13 Restarting the Program

If the Data Gathering program is in the computer, but has been halted for some reason, it can be restarted without loading from tape.

Action	Comment
Set ENABLE/DISABLE to ENABLE	Switches operative
RESET (momentary)	Run light out
Set switches to 406	In octal

EXAMINE (momentary)	406 in binary form appears in ADDRESS row of LED's A start address appears in DATA row of LEDS
Set switches to DATA indication	Binary
RESET (momentary)	
START (momentary)	Terminal spaces up one line
Type .RTOS$R	$ is produced by ESC key

The program starts by typing WELCOME TO THE...

SECTION 4

PLAYBACK

SECTION 4 - PLAYBACK

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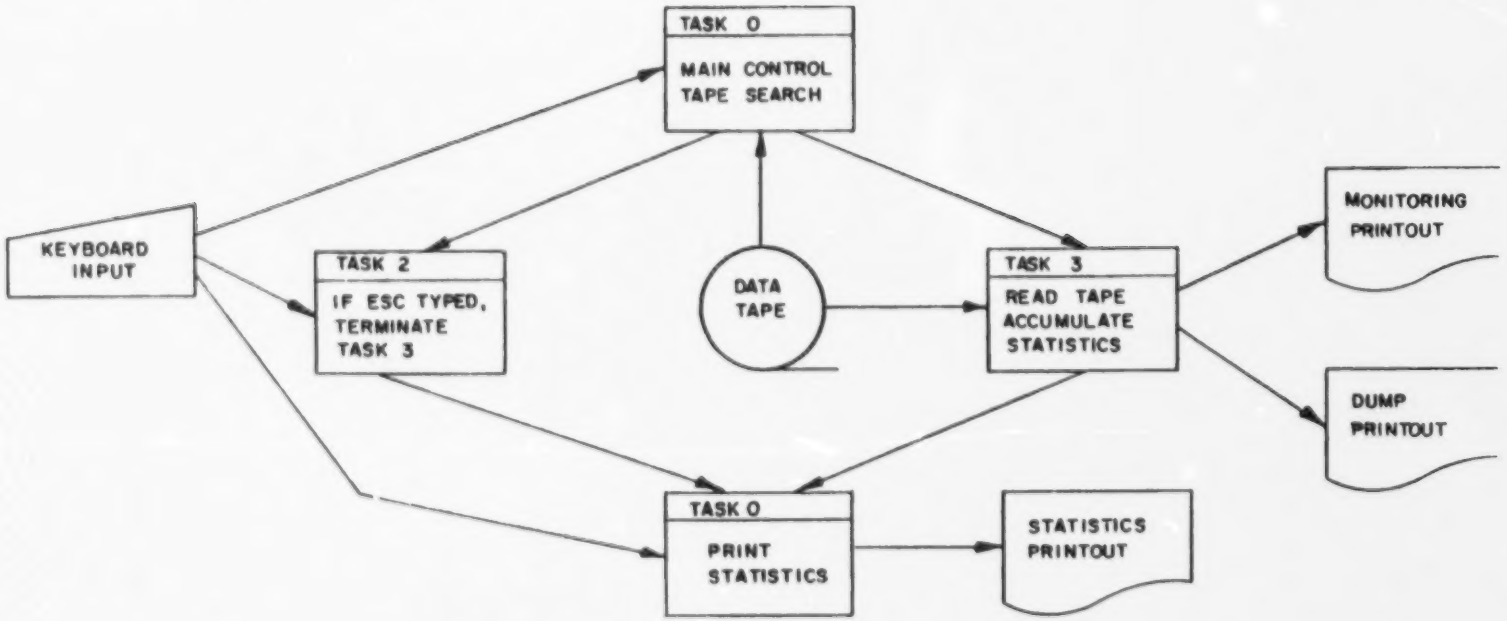

PLAYBACK PROGRAM

SECTION 4 - PLAYBACK

1. Read in Playback Program

   - Mount program tape on drive 0 / set to BOT
   - Enter Bootstrap leader in core

     60122 in location 376

     377 in location 377

   - Hit RESET, then START
   - Computer requests file number

     FROM MTO:

     Type the file number of the playback program, listed on the program tape real as PBSV

2. Initialization

   Computer types:

   1603 RTOS REV 5.50
   MOUNT TAPE FOR READING, TYPE UNIT # (0 or 1):

   Mount a data tape.

   Enter the unit # of the tape drive on which the data tape is mounted.

   Computer types:

   TYPE FILE ## OR 00

   (i) If data gathering was halted and then restarted while the tape was being recorded, each restart creates a new file. Files are numbered 00, 01, 02.... If the file number of the desired file is known, type it. Otherwise, type 00 to start at the beginning of the tape.

Computer types the start date and time of the tape file

FILE START 78Y 6M 14D 23M 11S

and the total sampling rate for this sampling pattern

2847.0 SAMPLES/SEC

3. Search Options

It then offers the operator four options:

1. TO START HERE
2. TO SEARCH FOR START TIME
3. TO SEARCH FOR ALARMS
4. TO MODIFY ALARMS
:

3.1 To start processing at the beginning of the file, type 1.

: 1

The computer asks

END DATE (Y OR N?)

3.2 Search by Time

To skip the first part of the file and start processing at some later (known) time, type 2.

: 2

The computer asks

YR,MO,DA:

Enter the year (two digits), month (1 or 2 digits) and day (1 or 2 digits), separated by commas. Ex:

YR,MO,DA: 78,6,14

The computer asks

HR,MI,SC:

Enter the hour (24-hour clock), minute and second (1 or 2 digits each), separated by commas. Ex:

HR,MI,SC: 14,23,20

The file is read until the requested time or a later time is found, or until end of file is encountered.

(i) If end of file is encountered, the computer types

START TIME NOT FOUND

EOF

and moves to Paragraph 7.2

(ii) If the requested time or a later time is encountered, the computer types

RECORD FOUND: yyY mmM ddD hhH mmM ssS

It then asks

END DATE (Y OR N)?

3.3 Search by Alarm

To search for file for the first value which exceeds its assigned alarm limits, type 3

: 3

The file is read until some value is found which exceeds its limit, or until the end of file is encountered.

(i) If end of file is encountered, the computer types

NO ALARMS EXCEEDED

EOF

and moves to section 7.2

(ii) If a value exceeding the alarm is encountered, the computer types

nnn LIMIT EXCEEDED where nnn is the sensor addresses

it then asks

END DATE (Y OR N)?

3.4 Modify Alarms

To modify alarm limits in preparation for search by alarm, type 4

: 4

The computer prints the following explanations once

1 TO EXAMINE ONE ADR

2 TO EXAMINE A RANGE

3 TO MODIFY ONE ADR

4 TO MODIFY A RANGE

(1-4):

Thereafter, just the last line is printed as a reminder to enter the day number. Type 0 (zero) or CNTL - Z to exit this section.

(i) To examine the status (sampling rate, mode, alarm limits, units) of a single sensor, type 1. Then the address is requested. Enter it, and the status is typed out. Example:

(1-4): 1

ADR: 128

128 5 R 256 768 -1000.00 1000.00 uS

(1-4):

(ii) To examine the status of a range of sensors, type 2. When the range is requested, type the lowest desired address and the highest desired address, separated by a comma. The status is typed out. Example:

(1-4): 2

A1,A2: 128,130

128 5 R 256 768 -1000.00 1000.00 uS

129 5 R 256 768 -1000.00 1000.00 uS

130 3 R 284 640 -500.00 500.00 uS

(1-4):

(iii) To modify the alarm limits for a single sensor, type 3. As indicated by the prompt, enter the address, the min, and the max, separated by commas. The computer modifies the alarm limits and prints the whole status line. Example

(1-4): 3

ADR,MN,MX: 128,384,640

128 5 R 384 640 -500.00 500.00 uS

(1-4):

To modify the alarm limits for a range of sensors, type 4. As indicated by the prompt, enter the low address, high address, min, and max, separated by commas. The computer modifies the alarm limits of all sensors in the indicated range but prints the status line for only the first and last addresses. Example:

(1-4): 4

A1,A2,MN,MX: 129,143,384,640

129 5 R 384 640 -500.00 500.00 uS

143 1 P 384 640 -2.50 2.50 VOLT

(1-4):

To terminate the alarm examine/modify routine, enter a zero, or type CNTL - Z. The search option list is offered again (as at the start of Paragraph 3).

3.5 End Date and Time

When the computer asks

END DATE (Y OR N)?

(i) To specify a final date and time to be processed, type Y.
The computer asks

YR,MO,DA:

Enter year (two digits), month (one or two digits) and day (one or two digits). Numbers must be separated by commas. Example

YR,MO,DA: 78,6,14

The computer asks

HR,MI,SC:

Type hour (24-hour clock), minute and second (one or two digits each) separated by commas.

HR,MI,SC: 14,23,30

(ii) To process right to the end of file, or to stop processing manually, type N.

3.6 Printout Options

When the start point has been established and located, the computer offers the processing options. In all cases, statistics are accumulated as the tape is read.

1 MONITORING

2 DUMP

:

4. Monitoring

To print one selected sensor, type 1

: 1

The computer asks which address (sensor) you wish to print out

ADR:

Type the sensor number. Example:

ADR: 128

The computer types information about the sensor as recorded:

128 SAMPLED AT 250/SEC IN REAL MODE

RECORDED LIMITS 512 768 0.00 1000.00 uS

Then it asks for monitoring limits. All values exceeding these limits are printed with an asterisk, and the number of such values is counted. Enter the limits as in the data acquisition program. Example:

MONITORING LIMITS: 256,768

The computer responds by typing the converted limits and appropriate units. Example:

-1000.00 1000.00 uS

The program can print all values of the selected sensor, or every second value, or every nth value. The computer asks:

MONITOR EVERY NTH READING. N:

Respond 1 to print every value, or 10 to print every tenth value, etc. The computer then asks whether or not printout is desired. Answer Y or N. Example:

TYPE? Y

The computer will then read the tape, accumulate statistics, and optionally print the requested values until:

a) the end time (if selected) is reached, or

b) the end of file is encountered, or

c) the operator terminates printing by typing the ESC key.

Then the monitoring statistics are printed out.

nnn. VALUES IN units	the number of monitored values and units
nnn. VALUES - 1000.00	the number of monitored values less than the monitoring minimum
nnn. VALUES 1000.00	the number of monitored values greater than the monitoring maximum

MIN: N.NN MAX n.nn MEAN n.nn RMS n.nn units

MIN, the smallest of all monitored values

MAX, the largest of all monitored values

RMS, the root-mean-square of all monitored values

MEAN, the mean of all monitored values

nnn TAPE RECORDS READ

5. Dump

To print all values on the tape, or to accumulate statistics without printout, type 2.

: 2

The computer asks whether or not printout is desired Answer Y or N. Example:

TYPE? Y

The program then reads the tape, accumulates statistics, and optionally prints all values until

a) the end time (if selected) is reached, or

b) the end of file is encountered, or

c) the operator terminates printing by typing the ESC key.

6. End Printout

6.1 Time Printout

(i) If an end time was selected, and processing was stopped because a later time was encountered, the following information is printed:

the time of the last record actually processed:

LAST TIME yyY mmM ddD hhH mmM ssS

the end time selected by the operator:

END TIME yyY mmM ddD hhH mmM ssS

the time of the next record (read, but not processed)

THIS TIME yyY mmM ddD hhH mmM ssS

(ii) If processing was stopped because end of file was encountered, only the time of the last record processed is printed:

LAST TIME yyY mmM ddD hhH mmM ssS

6.2 Statistics

At the end of processing, various statistics are available covering all data (whether or not printed out) read from the tape. These may be printed out at the operator's direction. The information available for each sensor is:

1. Sensor address, rate and mode.
2. Alarms in effect when the tape was recorded, or as modified by the operator.
3. Number of records (values) read for this sensor.
4. Number of values less than the assigned minimum.
5. Number of values greater than the assigned maximum.
6. Minimum value read.
7. Maximum value read.
8. Mean of all values read.
9. Root-mean-square of all values read.

Two printout formats are available, long form and short form. If the long form is selected, all items (1-9) listed above are printed. For the short form, only items 1 and 6-9 are printed.

Printout of statistics is optional. The computer asks

TYPE STATISTICS ?

The legal responses and their meanings are:

1. NO - no printout is desired; proceed to Paragrpah 7.1
2. AL - print all sensors in long format; then proceed to paragraph 7.1 (should be selected only if wide paper is loaded in the printer).
3. AS - print all sensors in short format; then proceed to Paragraph 7.1.
4. YL - print (yes) selected sensors in long format (see below) (Should be selected only if wide paper is loaded in the printer).
5. YS - print (yes) selected sensors in short format (see below)
6. YE - print (yes) selected sensors; format specified with each selection.

When selected sensors at to be printed (YL,YS,YE) the computer types

ENTER ADRI, ADR2:

:

to remind the operator what it wants. Therafter it types only the colon to request sensor selection. Statistics are typed for sensor ADRI through ADR2, inclusive. Two addresses mut be entered, separated by a comma. If only one line of output is desired, type the same address twice. Example:

: 1,10	*types statistics for sensors 1-10 inclusive*
: 128,128	*types statistics for sensor 128*

If the output format (YS or YL) was selected originally, tne statistics are typed immediately. If not (YE), agter each sensor address selection the computer asks.

LONG OR SHORT?

Type L for long or S for short. L should not be selected unless the wide paper ti loaded in the printer. When all desired statistics have been typed, respond CONTROL Z (hold down the CONTROL button, and type Z) when the colon appears.

7. Resume Processing Options

7.1 Continuation Option

If processing was halted due to exceeding the specified end time, it is possible to continue processing without re-zeroing the statistics accumulators. The computer asks

CONTINUE?

To resume the same processing option (moitoring or dump) without zeroing the statistics, type Y. The computer asks for END DATE, as in Paragraph 3.5 and then resumes processing.

To zero the accumulators and start anew compling statistics, type N.

7.2 Further Processsing Options

The computer offers four options for further processing:

1 NEW OUTPUT

2 NEW SEARCH

3 NEW FILE

4 NEW TAPE

:

1) To continue from the present point in the file, but with the opportunity to select a new printout option, type 1, and start again at Paragraph 3.6.

: 1

2) To establish a new starting point for processing (new start time or alarms to search for), type 2, and start again at Paragraph 3.

: 2

3) To search another file on the same tape, type 3 and start again at Paragraph 2.

: 3

4) To process a new tape, or to terminate playback, type 4.

: 4

SECTION 5

TEST MODES

SECTION 5 - TEST MODES

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a) Sample and Halt, Single Address: Check Values
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SECTION 5 - TEST MODES

1. Test Routines, General

The data acquisition program has four types of test routines built into it to assist in the setup and debugging of hardware:

a) Continuous addressing loops to permit oscilloscope inspection of the various bus lines and card select functions.

b) Sample and halt programs where an individual sensor is addressed, and the analog response is converted to digital form and displayed.

Both types of program can be run in a single address or incrementing manner, and can be used to test alarms and auto-zero functions as well as addresses.

It is not possible to send alarms A, B or C, or auto-zero signal concurrently with an address.

See Paragraph 5 for an explanation of results printed by sample and halt modes.

In the italic sections shown for terminal printout, an underline is used to show existing printout on the same line.

The $ is obtained by typing the ESC key.

(CR) indicates the RETURN key. Some lines require the (CR and some do not.

It is not possible to read box 0, card 0 in peak mode (all swtiches down).

If the expected results printout or scope loop) are not obtained, check whether the CARRY light on the computer is flashing. This indicates that the computer is not getting the required signals back from the interface. See Trouble Shooting, Paragraph 6.

2. Program Availability

The test routines are built into the data acquistion program which may be resident in core memory from a previous load.

If the program is not in memory, it will ne necessary to load it as indicated in Section 2.

To activate the test sequence the following commands must be entered through the computer panel. See Paragraph 4 below.

3. Operating the Test Routine - Step by Step

Step 1. Get the start address in loation 406

- ENABLE/DISABLE switch to ENABLE position.
- Hit RESET (RUN light out).
- Set panel switches to 406.
- Hit EXAMINE.

406 appears in top row of loghts.
Start address appears in bottom row of lights.

Step 2. Start the test setup sequence.

- Load start address from bottom row of lights into switches.
- Hit RESET then START switches on computer.
  Terminal spaces up one line.

Step 3. Choose test option.

a) Sample and Halt, Single Address: Check Values.
b) Continuous Sampling, Single Address: Oscilloscope Loop.
c) Sample and Halt, Increment Address: Check Values
d) Continuous Sampling, Increment Address: Oscilloscope Loop.

Note that "$" in these instructions and typed out by the computer is produced by the "ESC" key.

a) Sample and Halt, Single Address.

Type *TEST+24$B*

Type *TEST+1/*

A number is typed out:

If it is *401* type *(CR)*

If not, type *401 (CR)*.

Set desired address in switches

Type *TEST$R* (to run).

The program sends the address or command to the interface, waits for a response from the hardware, types the results.

Repeat as required.

Change the address if desired.

Type *$P* to send this address (to proceed).

Repeat as required.

If no response is typed, no response is coming from the interface.

Check first that power is on. Restart at Step 2.

Try both alarms and addresses to see which is not responding.

b) Continuous Sampling, Single Address.

Type *$D*

Type *TEST+1/*

A number is typed out:

If it is *401*, type *(CR)*.

if not, type *401 (CR)*.

Set desired address in switches

Type *TEST$R*

The program loops endlessly.

Change the address if desired. Procedure as in a) above.

To switch to another test option, restart at Step 1.

Note: If the CARRY light on the upper left of the computer flashes, no response is received. Changing the address is ineffective. Start at Step 1 and run sample and halt test. (Check power is ON to the interface and boxes.)

c) Sample and Halt, Increment Address.

Type *TEST+24$B*

Type *TEST+1/*

A number is typed out

If it is *402*, type *(CR)*.

If not, type *402 (CR)*.

Type *TEST+36/*

A number is typed out.

If it is the desired highest address, type *(CR)*

If not, type desired highest address *(CR)*

Set in switches lowest address to be sampled.

Type *TEST$R* (to run).

The program sends the address,
waits for a response,
types the results,
increments the address and,
if incremented address top address,
restarts at address in switches.

Type *$P* to proceed.

d) Continuous Sampling, Increment Address

Type *$D*

Type *TEST+1/*

A number is typed out.

If it is *402*, type *(CR)*.

If not, type *402, (CR)*.

Type *TEST+36/*

A number is typed out.

If it is the desired highest address, type *(CR)*

If not, type *desired highest address (CR)*

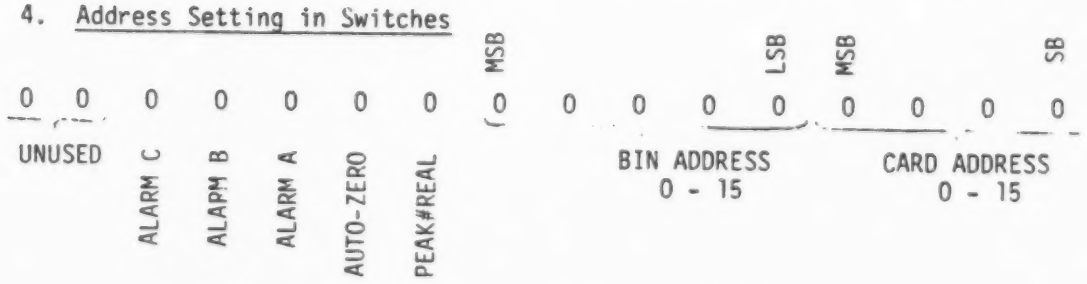
Set in switches lowest address to be sampled.

Type *TEST$R* (to run).

The program sends the address,
waits for a response,
delays 1/2 ms,
increments the address and,
if incremented address top address,
restarts at address in switches,
loops to send address.

To switch to another test option, restart at Step 1.

4. Address Setting in Switches



a) Switch 2 up, all others down for Alarm C.
b) Switch 3 up, all others down for Alarm B.
c) Switch 4 up, all others down for Alarm A.
d) Switch 5 up, all others down for zero amplifiers.
e) Sensor addresses:

Switches 0-5 down
Switch 6 up for real mode, down for peak mode
Switch 7 down
Switches 8-11 bin address, 0 thru 15 in binary
(MSB left, LSB right)
Switches 12-15 card address, 0 thru 15 binary,
(MSB left, LSB right)

5. Results from Sample and Halt Mode

The program types output in the form

$B TEST +23

AAAAAA 1 BBBBBB 2 CCCCCC 3 DDDDDD

AAAAAA indicates the switch setting (in Octal).

BBBBBB ignore for the alarms, zero amplifiers
for sensor addresses = returned value (in Octal).

000000 = -10 V
001000 = 0 V See Conversion Chart, end of Section.
001777 = +10 V
For values 2000 and greater, time out on the A to D converter* occurred. Subtract 2000 and use the table above.

* Timeout on the A to D Converter: In the present configuration, a reading greater than 2000 on A seems to indicate noise on the lines rather than actual timeout. Timeout has actually occureed when D reads higher than 4000.

CCCCCC number of counts (in Octal) till IN CLK received. Should be:

000000	for alarms, zero amplifiers.
000024	for sensor addresses.

DDDDDD number of counts (in Octal) till EXT GATE received. Should be:

000000	for sensor addresses, alarms
000275	for zero amplification. (approx. 272-277)
003004	for no command (approx. 2724-3404) all switches down, or only 0 or 1 up)
004000	or greater for timeout on the A to D Converter.

6. Trouble-Shooting

Any trouble-shooting should begin with the single address, sample and halt test loop.

At least one sample should be taken with:

Each alarm separately	(timing words 000000 and 000000)
The auto zero function	(timing words 000000 and 000275)
An address in real mode	(timing words 000023 and 000000)
An address in peak mode	(timing words 000023 and 000000)

- If no response is received (no printout, CARRY light flashes, RUN light on) for any input, the EXT GATE signal is not received. Check EXT GATE circuit (relates to OUT BUSY, time delays).

- If alarms and auto-zero respond, but no response is received when an address is sent, the IN CLK signal is not received. Check IN CLK circuit (relates to IN BUSY).

- If the timing printout is not as specified above $^{+}1$ is OK on the values. i.e., 23 or 24 OK for addresses), check the appropriate timing circuits.

- In case of any one of the above malfunctions, the scope loop form of the single address test will be useful in tracking down the problem.

Then use the sample and halt loop to test A-D conversion by cycling one card through its range with a simulated load. Verify that all values are reported correctly per the following table:

Reading	Volts	Reading	Volts
0000	-10.00	1000	0.00
0032	- 9.50	1032	0.50
0040	- 9.38	1040	0.63
0063	- 9.00	1063	1.00
0100	- 8.75	1100	1.25
0115	- 8.50	1115	1.50
0140	- 8.13	1140	1.88
0146	- 8.00	1146	2.00
0200	- 7.50	1200	2.50
0232	- 7.00	1232	3.00
0240	- 6.88	1240	3.13
0263	- 6.50	1263	2.50
0300	- 6.25	1300	3.75
0315	- 6.00	1315	4.00
0340	- 5.63	1340	4.38
0346	- 5.50	1346	4.50
0400	- 5.00	1400	5.00
0436	- 4.50	1432	5.50
0440	- 4.38	1440	5.63
0463	- 4.00	1463	6.00
0500	- 3.75	1500	6.25
0515	- 3.50	1515	6.50
0540	- 3.13	1540	6.88
0546	- 3.00	1546	7.00
0600	- 2.50	1600	7.50
0632	- 2.00	1632	8.00
0640	- 1.88	1640	8.13
0663	- 1.50	1663	8.50
0700	- 1.25	1700	8.75
0715	- 1.00	1715	9.00
0740	- 0.63	1740	9.38
0746	- 0.50	1746	9.50
1000	0.00	1777	9.98

Conversion Chart

APPENDIX A - AN INTRODUCTION TO OCTAL REPRESENTATION

Numbers specified for operations via the computer front panel switches will always be specified in Octal form to coincide with the front panel markings. (See Figure 1.)

However, entry is executed in binary terms, for example:

Address	0 0 1 1 0 1 0 0 1 0 0 0 1 0 1
Data	0 1 1 0 0 0 1 1 1 1 0 1 0 0 1 1
Switch	0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

Such instructions and print-out are 16 bit binary numbers which are easy to misread and almost impossible to remember. Octal format allows these binary numbers to be expressed in an equivalent form, which is considerably easier to use and remember.

Consider the switch settings grouped into units of 3, except for the L.H. switch, with which one may visualize two imaginary switches to its left, always set to 0 as indicated in Figure 1.

The binary number set on the switches as:

0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

may be rewritten in groups of three as:

0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

and converted to octal format according to the following table:

Binary	Octal
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Similarly, address, data and switch representation may be grouped and converted thus:

Position	0	1/2/3	4/5/6	7/8/9	10 11 12	13 14 15	
Address		0 0 1	1 0 1	0 0 1	0 0 0	1 0 1	Binary
		1	5	1	0	5	Octal
Data	(0 0)0	1 1 0	0 0 1	1 1 1	0 1 0	0 1 1	Binary
	0	6	1	7	2	3	Octal
Switch	(0 0)0	0 0 0	0 0 0	0 1 1	1 1 1	1 1 1	Binary
	0	0	0	3	7	7	Octal

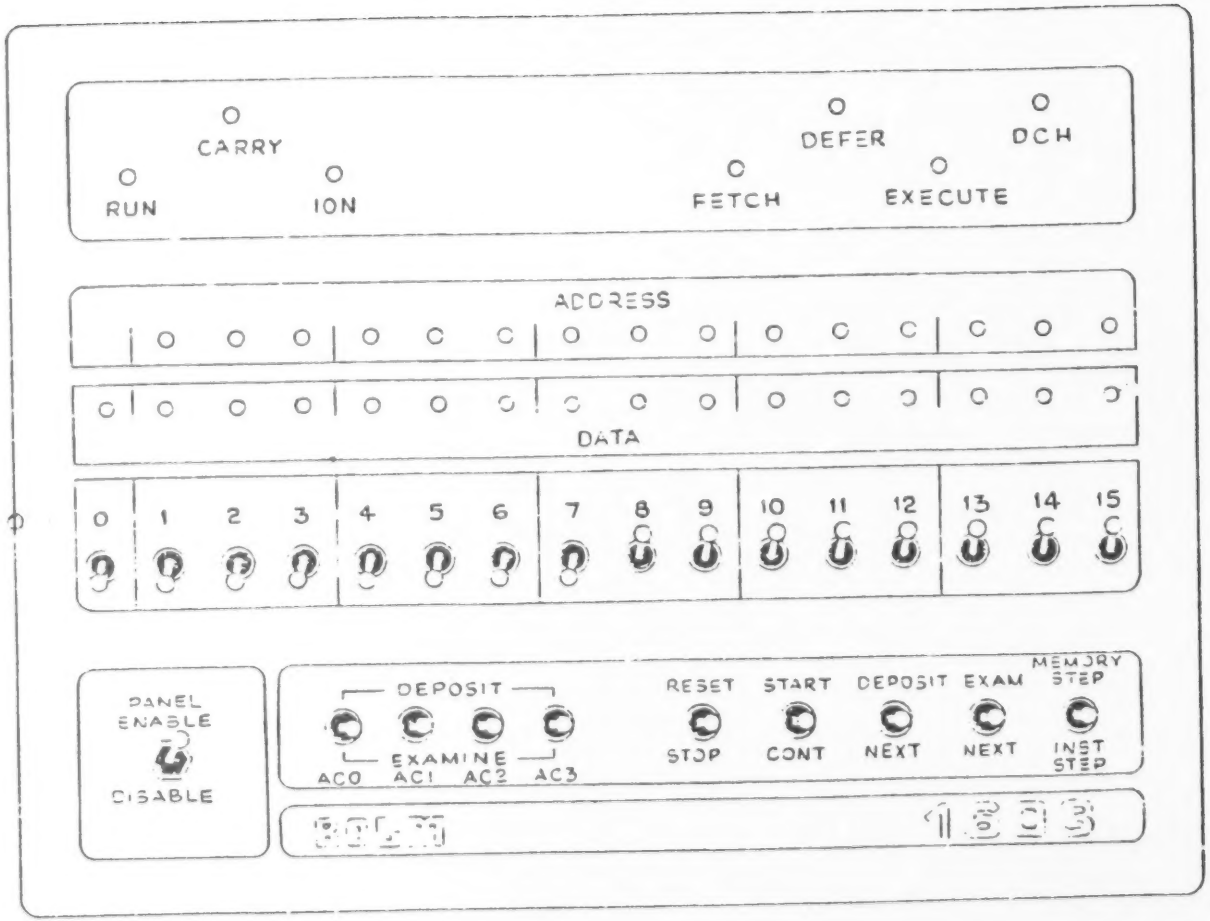


FIGURE 1 - ROLM 1603A COMPUTER INTEGRAL CONTROL PANEL

Within a group of three switches, the right hand switch is given a value of 1, while the middle and left hand switches are given values of 2 and 4 respectively. This, in the example above, the 13, 14 and 15 switches represent a value of:

4 + 2 + 1 = 7
LHS C RHS OCTAL

Similarly, the data lights 10, 11 and 12 become:

0 + 2 + 0 = 2
LHS C RHS OCTAL

APPENDIX B - ALPHABETICAL LISTING AND BINARY ADDRESSES OF SENSORS

Function	Channel No.	Box No.	Bin. No.	Bin. Binary Address	Card No.	Card Binary Address
Accelerometer - Surge	1	1	0	00000	1	0001
Accelerometer - Sway	2	1	0	00000	2	0010
Accelerometer - Heave	31	1	1	00001	15	1111
Accelerometer - Surge	212	6	13	01101	4	0100
Accelerometer - Sway	213	6	13	01101	5	0101
Accelerometer - Heave	214	6	13	01101	6	0110
Air Temperature	231	7	14	01110	7	0111
Barometric Pressure	228	7	14	01110	4	0100
Barometric Pressure	229	7	14	01110	5	0101
Barometric Pressure	230	7	14	01110	6	0110
Bubbler Valve Status	204	6	12	01100	12	1100
Bubbler Valve Status	205	6	12	01100	13	1101
Bubbler Valve Status	206	6	12	01100	14	1110
Bubbler Pressure	187	5	11	01011	11	1011
Bubbler Pressure	188	5	11	01011	12	1100
Cloud Cover	225	7	14	01110	1	0001
Engine RPM	241	7	15	01111	1	0001
Fuel Rack	199	6	12	01100	7	0111
Ice Cover	226	7	14	01110	2	0010
Pitch	239	7	15	01111	0	0000
Prop. Command	244	7	15	01111	4	0100
Prop. Control	193	6	12	01100	1	0001
Prop. Response	201	6	12	01100	9	1001
Relative Humidity	232	7	14	01110	8	1000
Roll	240	7	15	01111	0	0000
Rudder Angle	200	6	12	01100	7	0111
Rudder Command	245	7	15	01111	4	0100
Rudder Torque	192	6	12	01100	0	0000
Shaft RPM	242	7	15	01111	2	0010
Shaft Torque	194	6	12	01100	2	0010
Shaft Torque	195	6	12	01100	3	0011
Ships Head - Cosine	238	7	14	01110	14	1110
Ships Head - Sine	237	7	14	01110	13	1101
Ships Speed	236	7	14	01110	12	1100

Function		Channel No.	Box No.	Bin. No.	Bin. Binary Address	Card No.	Card Binary Address
Strain Gauge	1035	176	5	11	01011	0	0000
	1045	177	5	11	01011	1	0001
	1055	178	5	11	01011	2	0010
	1055	179	5	11	01011	3	0011
	1055	180	5	11	01011	4	0100
	1055	181	5	11	01011	5	0101
	1055	182	5	11	01011	6	0110
	1055	183	5	11	01011	7	0111
	1065	184	5	11	01011	8	1000
	1075	185	5	11	01011	9	1001
Strain Gauge	1785-1	128	4	8	01000	0	0000
	1790-2	129	4	8	01000	1	0001
	1790-3	130	4	8	01000	2	0010
	1790-4	131	4	8	01000	3	0011
	1790-5	132	4	8	01000	4	0100
	1790-6	133	4	8	01000	5	0101
	1790-7	134	4	8	01000	6	0110
	1790-101	12	1	0	00000	12	1100
	1790-100	11	1	0	00000	11	1011
	1790-121	135	4	8	01000	7	0111
	1790-122	136	4	8	01000	8	1000
	1790-123	137	4	8	01000	9	1001
	1790-124	138	4	8	01000	10	1010
	1790-171	13	1	0	00000	13	1101
	1795-8	139	4	8	01000	11	1011
	1805-9	140	4	8	01000	12	1100
	1810-10	141	4	8	01000	13	1101
	1810-11	142	4	8	01000	14	1110
	1810-12	144	4	9	01001	0	0000
	1810-13	145	4	9	01001	1	0001
	1810-14	150	4	9	01001	6	0110
	1810-15	151	4	9	01001	7	0111
	1810-102	14	1	0	00000	14	1110
	1810-125	146	4	9	01001	2	0010
	1810-126	147	4	9	01001	3	0011
	1810-127	148	4	9	01001	4	0100
	1810-128	149	4	9	01001	5	0101
	1810-172	15	1	0	00000	15	1111
	1810-173	16	1	1	00001	0	0000
	1815-16	152	4	9	01001	8	1000
	1825-17	153	4	9	01001	9	1001
	1825-191	167	4	10	01010	7	0111
	1825-192	168	4	10	01010	8	1000
	1825-193	169	4	10	01010	9	1001
	1830-18	154	4	9	01001	10	1010
	1830-19	155	4	9	01001	11	1011
	1830-20	156	4	9	01001	12	1100
	1830-21	157	4	9	01001	13	1101

Function		Channel No.	Box No.	Bin. No.	Bin. Binary Address	Card No.	Card Binary Address
Strain Gauge	1830-22	158	4	9	01001	14	1110
	1830-23	160	4	10	01010	0	0000
	1830-24	161	4	10	01010	1	0001
	1830-25	162	4	10	01010	2	0010
	1830-26	163	4	10	01010	3	0011
	1830-27	164	4	10	01010	4	0100
	1830-28	165	4	10	01010	5	0101
	1830-29	166	4	10	01010	6	0110
	1830-103	18	1	1	00001	2	0010
	1830-129	173	4	10	01010	13	1101
	1830-130	174	4	10	01010	14	1110
	1830-131	81	3	5	00101	1	0001
	1830-132	84	3	5	00101	4	0100
	1830-143	80	3	5	00101	0	0000
	1830-144	82	3	5	00101	2	0010
	1830-145	83	3	5	00101	3	0011
	1830-174	17	1	1	00001	1	0001
	1830-194	170	4	10	01010	10	1010
	1835-30	85	3	5	00101	5	0101
	1840-50	127	3	7	00111	15	1111
	1840-93	105	3	6	00110	9	1001
	1840-94	106	3	6	00110	10	1010
	1840-95	107	3	6	00110	11	1011
	1840-96	108	3	6	00110	12	1100
	1840-201	101	3	6	00110	5	0101
	1845-31	86	3	5	00101	6	0110
	1850-32	87	3	5	00101	7	0111
	1850-33	88	3	5	00101	8	1000
	1850-34	89	3	5	00101	9	1001
	1850-35	90	3	5	00101	10	1010
	1850-36	91	3	5	00101	11	1011
	1850-37	92	3	5	00101	12	1100
	1850-104	19	1	1	00001	3	0011
	1850-133	93	3	5	00101	13	1101
	1850-134	94	3	5	00101	14	1110
	1850-135	95	3	5	00101	15	1111
	1850-136	96	3	6	00110	0	0000
	1850-137	97	3	6	00110	1	0001
	1850-138	98	3	6	00110	2	0010
	1850-139	99	3	6	00110	3	0011
	1850-175	20	1	1	00001	4	0100
	1850-202	102	3	6	00110	6	0110
	1850-203	103	3	6	00110	7	0111
	1850-204	104	3	6	00110	8	1000
	1855-38	100	3	6	00110	4	0100
	1865-39	109	3	6	00110	13	1101
	1865-40	110	3	6	00110	14	1110
	1870-41	111	3	6	00110	15	1111
	1870-42	112	3	7	00111	0	0000
	1870-43	113	3	7	00111	1	0001
	1870-44	114	3	7	00111	2	0010

Function		Channel No.	Box No.	Bin. No.	Bin. Binary Address	Card No.	Card Binary Address
Strain Gauge	1870-105	21	1	1	00001	5	0101
	1870-140	115	3	7	00111	3	0011
	1870-141	116	3	7	00111	4	0100
	1870-142	117	3	7	00111	5	0101
	1870-176	22	1	1	00001	6	0110
	1875-46	118	3	7	00111	6	0110
	1885-51	119	3	7	00111	7	0111
	1890-52	120	3	7	00111	8	1000
	1890-53	121	3	7	00111	9	1001
	1890-54	122	3	7	00111	10	1010
	1890-55	123	3	7	00111	11	1011
	1890-56	124	3	7	00111	12	1100
	1890-106	23	1	1	00001	7	0111
	1890-147	125	3	7	00111	13	1101
	1890-148	126	3	7	00111	14	1110
	1890-149	32	2	2	00010	0	0000
	1890-150	33	2	2	00010	1	0001
	1890-177	24	1	1	00001	8	1000
	1895-92	34	2	2	00010	2	0010
	1905-57	35	2	2	00010	3	0011
	1910-58	36	2	2	00010	4	0100
	1910-59	37	2	2	00010	5	0101
	1910-60	38	2	2	00010	6	0110
	1910-61	39	2	2	00010	7	0111
	1910-62	40	2	2	00010	8	1000
	1910-90	41	2	2	00010	9	1001
	1910-91	42	2	2	00010	10	1010
	1910-107	26	1	1	00001	10	1010
	1910-151	43	2	2	00010	11	1011
	1910-152	44	2	2	00010	12	1100
	1910-153	46	2	2	00010	14	1110
	1910-161	45	2	2	00010	13	1101
	1910-178	25	1	1	00001	9	1001
	1915-63	48	2	3	00011	0	0000
	1925-64	49	2	3	00011	1	0001
	1925-65	50	2	3	00011	2	0010
	1930-66	51	2	3	00011	3	0011
	1930-67	52	2	3	00011	4	0100
	1930-68	53	2	3	00011	5	0101
	1930-154	54	2	3	00011	6	0110
	1930-155	55	2	3	00011	7	0111
	1930-179	27	1	1	00001	11	1011
	1935-69	57	2	3	00011	9	1001
	1935-70	58	2	3	00011	10	1010
	1945-71	59	2	3	00011	11	1011
	1945-72	60	2	3	00011	12	1100
	1945-108	28	1	1	00001	12	1100
	1950-74	62	2	3	00011	14	1110
	1950-75	63	2	3	00011	15	1111
	1950-76	64	2	4	00100	0	0000

Function		Channel No.	Box No.	Bin. No.	Bin. Binary Address	Card No.	Card Binary Address
Strain Gauge	1950-77	65	2	4	00100	1	0001
	1950-109	29	1	1	00001	13	1101
	1950-157	66	2	4	00100	2	0010
	1950-158	67	2	4	00100	3	0011
	1955-78	68	2	4	00100	4	0100
	1955-79	69	2	4	00100	5	0101
	1965-80	70	2	4	00100	6	0110
	1970-81	71	2	4	00100	7	0111
	1970-82	72	2	4	00100	8	1000
	1970-83	73	2	4	00100	9	1001
	1970-159	74	2	4	00100	10	1010
	1970-160	75	2	4	00100	11	1011
	1970-180	30	1	1	00001	14	1110
	1975-84	76	2	4	00100	12	1100
	1985-85	77	2	4	00100	13	1101
	1990-86	78	2	4	00100	14	1110
	1995-87	79	2	4	00100	15	1111
	2005-88	3	1	0	00000	3	0011
	2015-89	4	1	0	00000	4	0100
Temperature 1		5	1	0	00000	5	0101
2		6	1	0	00000	6	0110
3		7	1	0	00000	7	0111
4		8	1	0	00000	8	1000
5		9	1	0	00000	9	1001
6		10	1	0	00000	10	1010
7		171	4	10	01010	11	1011
8		172	4	10	01010	12	1100
Thrust		198	6	12	01100	6	0110
Visibility		224	7	14	01110	0	0000
Wind Direction		234	7	14	01110	10	1010
Wind Speed		233	7	14	01110	9	1001

PART III

CALIBRATION AND SETTING-UP PROCEDURES

PART III CALIBRATION AND SETTING-UP PROCEDURES

CONTENTS

SECTION 1 Introduction

SECTION 2 Amplifier Cards

SECTION 3 Master Cards

SECTION 4 Interface Buffer

SECTION 1. INTRODUCTION

The calibration and setting-up philosophy used in 1980 was to decide on the variable range to be measured on each channel and to make the necessary adjustments to obtain exactly that range. Because known settings are used for all the circuits it is then easy to bring the system back to its correct condition in the event of equipment drift or breakdown. Simple and unchanging conversion equations can then be used with the data recorded. This is believed to be preferable to simply calibrating the system without the preceding 'setting-up' operations as this would involve changing the conversion equations each time the system is used.

In setting up the system it is not sufficient to simply inject a signal into one of the sensors and monitor the computer output on the printer - there are just too many stages in the processing of the signal between the sensor and the final print-out, not to mention the logistics problems in monitoring the signal at the sensor and the printer output. Instead, it is recommended that the system be checked through stage by stage. The components of the signal processing that need adjustment are i) the amplifiers, ii) the master cards, and iii) the interface buffer. As is to be expected it is the analogue components of the system that are subject to drift and other marginal errors. Once the signal is converted into digital form, in the interface, computer, and tape, it will be transmitted and reproduced exactly.

The setting-up procedure used for the M.V. Arctic Data Acquisition System is explained in the following sections.

SECTION 2. AMPLIFIER CARDS

The controls on the amplifier card are the amplifier balance potentiometer, "AMP", the amplifier gain trim potentiometer, "GAIN", and the bridge balance potentiometers "BAL" that are connected in parallel with some of the sensors.

As a first step in the setting up procedure the amplifier card should be plugged into an extender board and a jumper connected across the loops on the amplifier board. This short circuits the input to the amplifier so an extender board should be used which breaks the connection between the sensor and amplifier input to prevent drawing too much current from the sensor. Next connect a DVM between "REF" and ground (eg. OV test point on M/C) and check that the amplifier reference voltage Vref is as specified in the manual. Then connect the DVM between "RL" and ground and adjust the "AMP" trim potentiometer so that the voltage reading is the same as Vref. The amplifier is now correctly balanced and the jumper lead can be removed and the card returned to its slot. Note, however, that on some channels the "AMP" control is used to compensate for offsets in the reference voltage or sensor outputs and the amplifier is used in a slightly unbalanced condition. The exact procedure to be used with each channel is detailed below.

Strain Gauges (Channels 16-30, 32-179)

Because of the auto zero circuitry used on the S/C amplifier cards, the reference voltage is lost whenever power is removed from the cards. When power is restored depress and release the 'Preset Auto Zero' switch on the M/C in order to reset the reference voltage to its nominal value (+5.22 volts).

Balance the amplifier as explained above but adjust the "AMP" trim potentiometer for a DVM reading of +5.0V $\pm$3mV.

Remove jumper lead and return the amplifier card to its slot. Press the 'Preset Auto Zero' again to restore the same reference voltage. Adjust "Coarse" and "Fire" balance, ie. C BAL and F BAL to set output at RL to 5.0V $\pm$5mV.

Insert 30K ohm test resistor between "CAL" and "GND" and adjust "GAIN" trim potentiometer so that output at RL is 0.00. The strain gauge will now give the correct full scale reading depending on its gauge factor.

The gauge factor is the proportionality constant relating the fractional change in length (strain) of the gauge to the fractional change in gauge resistance produced.

$$\varepsilon = \frac{\Delta L}{L} = \frac{1}{F} \times \frac{R}{R}$$

ε = strain
F = gauge factor

$$\Delta R = F.R.\varepsilon$$

Four different gauge factors are found amongst the strain gauges installed, so the range of strain measurements is different in the four cases. To establish the range it is necessary to determine the strain that will produce a change in strain gauge resistance of 0.48 ohms. (The 30K ohm calibration resistor produces a full scale deflection in output by simulating a 0.48 ohm change in strain gauge resistance.)

for F = 1.96 ΔR = 0.48 is produced by = 2040 μS
for F = 1.90 " " " " = 2100 μS
for F = 1.83 " " " " = 2180 μS
for F = 1.77 " " " " = 2260 μS

Accelerometers:	Channels			Channels	
	1	Heave		212	Surge
	2	Sway		213	Sway
	3	Surge		216	Heave

The accelerometers actually respond to the forces produced by accelerations. Consequently, the force of gravity can be used to calibrate the accelerometers. Each accelerometer is only sensitive to forces along its axis of operation, so tilting an accelerometer will change the effect of gravity on

it and produce a measureable output. For example, tilting the surge accelerometer down by 60° and by 90° produces an output corresponding to +0.5g and +1.0g. Similarly, tilting it up by 60° and 90° produces an output corresponding to -0.5g and -1.0g. The same procedure can also be used for the sway accelerometer where tilting 90° to starboard and port produces outputs of +1.0g and -1.0g respectively. The heave accelerometer is already aligned with the force of gravity so tilting the accelerometer by 90° in any direction produces an output of -1.0g. Turning the heave accelerometer through a total of 180° produces an output of -2.0g.

To set up accelerometers check that in their normal position (and with the ship at rest) the output at RL is +5.0 volts. Adjust the "AMP" and "BAL" trim potentiometers if necessary. Tilt the accelerometers and check that accelerometer outputs of -1.0g and +1.0g give amplifier outputs at RL of +3.0 volts and +7.0 volts respectively. Adjust "Gain" trim potentiometer if necessary.

Temperature (Channels 5-8)

Measure the temperature with a standard thermometer and compare with the amplifier output voltage.

Ship's Draft (Channels 252, 253)

Set draft switch at 7 metres and check output at RL is 0.0 volts. Adjust "AMP" trim potentiometer if necessary. Then set draft switch at 12 metres and check output at RL is +10.00 volts. Adjust "Gain" trim potentiometer if necessary.

Ship Speed (Channel 236)

With doppler log reading 0.0 knots check output at RL is 0.0 volts. Adjust "AMP" trim potentiometer if necessary. Set doppler log to TEST and wait for display to show 29.6 knots - then check output at RL is 9.9 volts. Adjust "Gain" trim potentiometer if necessary.

Ship's Head (Channels 237, 238)

When the ship is on different headings check that the correct output at RL is obtained as shown below.

Heading	Sine	Cosine	Ch 237	Ch 238
0°	0.0	1.0	+5V	+10V
90°	1.0	0.0	+10V	+5V
180°	0.0	-1.0	+5V	0V
270°	-1.0	0.0	0V	+5V

Pitch and Roll (Channels 239, 240)

Remove the mounting screws and tilt the gyro while monitoring each channel. For pitch positive means bow up, and for roll positive means roll to port.

With a tilt of 0° adjust "AMP" trim potentiometer so that the output at RL is +5.00 volts. Set tilt at +5° and adjust "Gain" trim potentiometer so that the output at RL is +10.00 volts. Change tilt to -5° and check that output at RL is 0.00 volts. Repeat above procedure if it is not.

Propellor Pitch Command and Response (Channels 244, 201)

Obtain the permission of the chief engineer and ask for power to be put on the control system. Then 2 people are needed: one on the bridge to set the pitch command and monitor the output of channel 244 in box 7, and one in the engine room to observe the pitch response indicator and to monitor the output of channel 201 in box 6. Communication between the bridge and engine room is difficult so arrange to go through a series of command settings, say -8, -4, 0, +4, +8, and hold each setting for 1 minute. Check on channels 244 and 201 that this produces outputs at RL of +1.0V, +3.0V, +5.0V, +7.0V and +9.0V.

Rudder Command and Response (Channels 245, 200)

These can be tested separately. Set rudder command at -40°C and check on channel 245 that the output at RL is +1.0 volts. Adjust "AMP" trim potentiometer if necessary.

Set rudder command at 0° and +40° and check that the output at RL goes to +5.0 volts and +9.0 volts. Adjust the "Gain" trim potentiometer if necessary.

To test rudder response have the rudder put on local control. Then it is possible to set the rudder at particular angles and check the amplifier card output (channel 200) as for the rudder command.

Thrust (Channel 198)

With reference to the manufacturer's instructions, zero the thrustmeter. This should be done when the engine oil is at operating temperature (ie. just after engine shutdown). When the thrustmeter is reading 0.0 tonnes check that the amplifier output at RL is reading 0.0 volts. Then switch the thrustmeter to 'TEST' to obtain a reading of 120 tonnes and check that the amplifier output at RL is 10.0 volts. Adjust "AMP" and "Gain" to obtain the correct amplifier output.

Adjust "AMP" and "Gain" to obtain the correct amplifier output.

Torquemeter (Channel 208)

When a torque is applied to the shaft, shear stresses are produced at the surface of the shaft and along the shaft. The tangential shear stress causes a twist in the shaft and a consequent shear strain (Fig. /). The shear stress along the shaft, however, produces a negligible strain because of the considerably greater rigidity of the shaft in this direction. Thus the basic equations are:

$$T = \frac{I}{R} \cdot G \cdot \gamma$$

where T = Torque (ft lbs)

R = Shaft radius (ft)

G = Shear Modulus = 1709.10^6 lbs/sq ft

γ = Angular Strain (ie. Shear strain)

I = Torsional Modulus = $\frac{\pi d^4}{32}$

and d = shaft diameter = 1.75 ft

And there is a linear relationship between Torque and Strain

T (ft lbs) = 1800 γ (μS)

The extensive strain, S, produces a change, R in the strain gauge resistance, R, given by

$\Delta S = \frac{\Delta R}{FR}$ where F = gauge factor

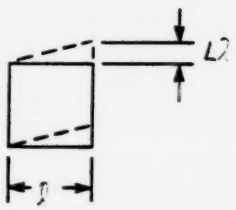
For the purpose of these calculations the gauge factor is asumed to be 2.0. Also R = 120 ohms

$\Delta R = 240. \Delta S = 120 \gamma$

When the shaft is subjected to a certain torque the resistance changes, Δ R, in each arm of the full strain gauge bridge produce a signal out equivalent to that produced by a 1/4 bridge with a resistance change, Δ R', where

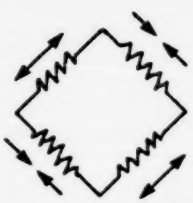
$\Delta R' = 4. \Delta R$

SHAFT



a) DISTORTION OF SURFACE ELEMENT BY A TORQUE, T.

SHAFT



b) RESULTING COMPRESSIVE STRAINS (→←) AND EXTENSIVE STRAINS (←→) PRODUCED IN THE STRAIN GAUGE BRIDGE.

FIGURE 1. A TORQUE, T, WILL TWIST THE SHAFT CAUSING A SHEAR STRAIN

$$\gamma = \frac{\Delta \ell}{\ell}$$

THIS PRODUCES:

COMPRESSIVE STRAINS, $-\Delta S = -0.5\ \gamma$
EXTENSIVE STRAINS, $+\Delta S = +0.5\ \gamma$

During the calibration procedure shunt resistors are connected across one arm of the bridge to simulate a strain by producing a resistance change $\Delta R'$.

Sample Calculation

Shunt one arm of bridge with a 200K resistor.

This gives $R' = 0.0714774$ ohms.

This gives a signal out equivalent to a full bridge with

$$R = \frac{R'}{4} = 0.0178694 \text{ ohms}$$

This would be produced by a shear strain

$$\gamma = \frac{\Delta R}{120} = 149.10^{-6}$$

The corresponding torque would thus be

$$T = 1800 \times 149$$

ie. $T = 268.10^3$ ft lbs

Calibration of the Torquemeter is done in two parts:

'Zero' Offset

Because of S/G drift and drifts in the F.M. telemetry system, zero torque does not produce 0 volts output from the torquemeter, so it is necessary to establish the 'zero' offset. To do this, it is not possible to simply take the reading when the shaft is stationary because friction in the bearings always results in a residual torque when the shaft stops. To overcome this, the shaft must be rotated slowly (using the turning gear) for one revolution, first one way and then the other,

while readings are taken every minute. The average of these readings can then be taken as the output level for zero torque.

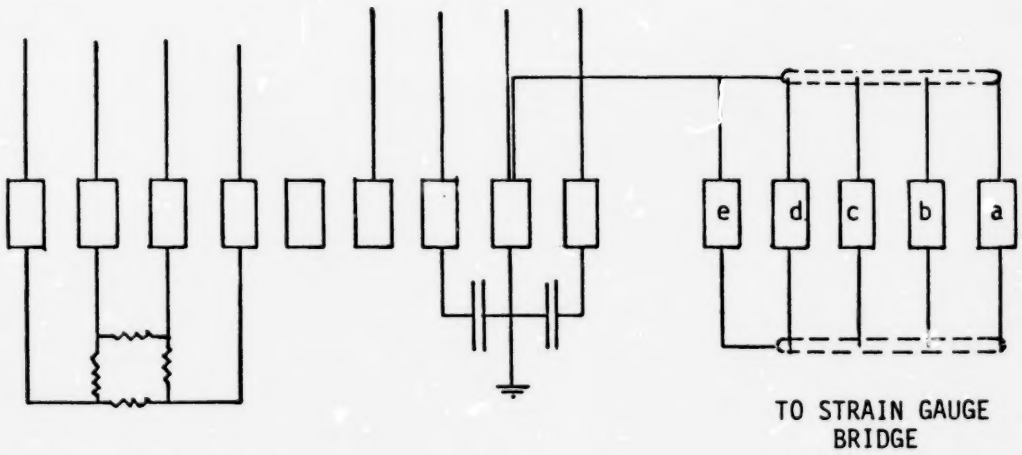
Slope

Due to the linear relationship between strain and torque, changing the S/G resistance to simulate a certain strain is equivalent to simulating the corresponding torque. This is done by shunting one arm of the S/G bridge on the shaft with known resistors. These should be connected across terminals 'b' and 'c' as shown in Fig. 2 Recommended shunt resistors, and corresponding torque values, are:

1 M Ω	52.10^3 ft lbs
400 K Ω	133.10^3 ft lbs
200 K Ω	268.10^3 ft lbs
150 K Ω	358.10^3 ft lbs
100 K Ω	537.10^3 ft lbs
75 K Ω	717.10^3 ft lbs
66 K Ω	815.10^3 ft lbs

Shaft RPM (Channel 211)

This equipment actually measures the period of shaft rotation and gives a voltage output (at test point REF) directly proportional to the period. To calibrate the system use a scope or counter connected to the RL test point of channel 209 to measure the time between pulses (ie. the period of revolution). Simultaneously measure the voltage at REF on Channel 211 and adjust the "Gain" and "AMP" trim potentiometers on Channel 211 to obtain a 10mV output for every millisecond of period.



TORQUEMETER CONNECTIONS ON THE SHAFT

FOR CALIBRATION CONNECT SHUNT RESISTORS ACROSS b AND c

FIG. 2.

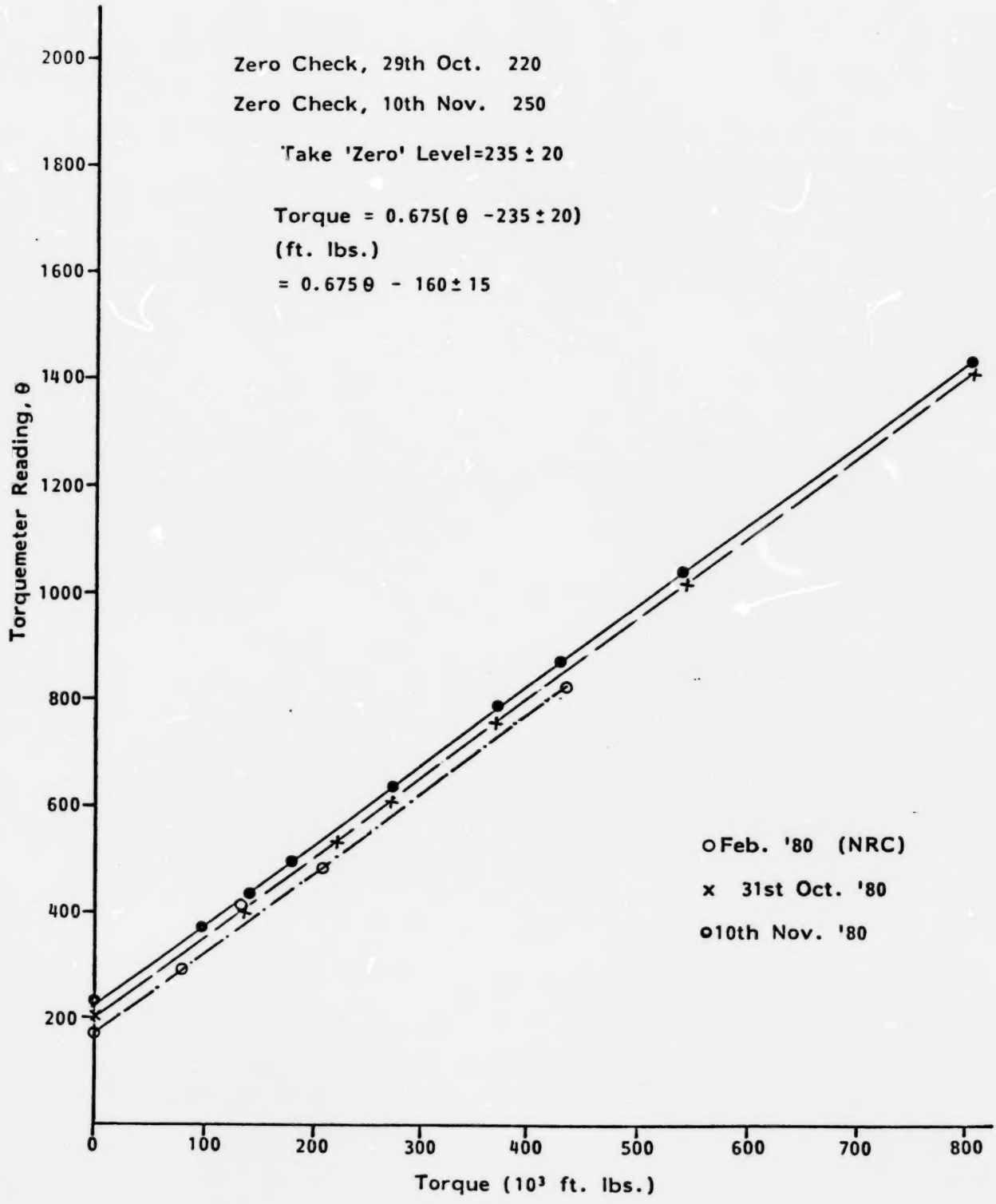


FIGURE 3. CALIBRATION OF TORQUEMETER

Manual Inputs (Channels 224-230, 232)

Change the manual input settings while monitoring the output from RL on the appropriate channel. With the setting on 0 adjust the "AMP" trim potentiometer to get an output of 0.0 volts. With the setting on 8 adjsut the "Gain" trim potentiometer to get an output of 8.0 volts.

Air Temperature (Channel 231)

Set the input at 0° and adjust the "AMP" trim potentiometer to obtain an output at RL of +5.00 volts.

Set the input at +40°C and adjust the "Gain" trim potentiometer to obtain an output of +9.00 volts. Change the input to -40°C and check that the output at RL is +1.00 volts. Repeat above procedure if error more than 10mV.

Wind Speed (Channel 233)

To check the anemometer installed it would be necessary to have an independent measure of wind speed (such as a hand- held anemometer). The anemometer should give an output of 0.07 volts/knot. The amplifier should then be checked that it gives outputs of +5V to +10V corresponding to 0 knots to 70 knots. (The winds, however, invariably fail to occur at the speeds suitable for calibrations.)

Wind Direction (Channel 234)

The synchro unit should be adjusted as per the manufacturer's instructions. When correctly set up the synchro-toanalogue converter should give outputs

of -10 volts to +10 volts for angles of 1° to 360°, and should switch from +10 volts to -10 volts as the angle changes from 360° to 1°.

With the wind vane clamped as for winds from an angle of 180° relative to the ship's head adjust the "AMP" trim potentiometer so that the output at RL is +5.00 volts. Set the wind vane for winds from 270° relative to the ship's head and adjust the "Gain" trim potentiometer so that the output at RL is +7.50 volts.

Set the wind vane for winds from 90° relative to the ship's head and check that the output from RL is +2.50 volts.

SECTION 3. MASTER CARDS

To test the master cards a special test amplifier card was made up to provide an amplifier card output that could be set to 0 to +10V in IV increments. For each bin this card was plugged into a spare socket and that channel addressed. A print-out was then obtained in the laboratory for the whole range of inputs. The results are shown in Table 1.

To bring all the master cards into line adjustments of the 'bus level' potentiometer on each card were made using the following procedures.

1. Put 'test' amplifier card and M/C in test rig and connect 'Real' output to the master card 'Signal In'.
2. Set the 'Real' output to +5V.
3. Connect a jumper lead between the '+15' and 'CE' test points on the master card - this switches on the bus driver circuits.
4. Connect a DVM to the 'Bus Y' and 'Bus Z' test points and adjust the BUS LEVEL pot. for a reading of 0.0V + 1mV.
5. Set 'test' card output to 0V and check DVM reads -10.00V $\pm$ 10mV.
6. Set 'test' card output to +10V and check DVM reads +10.00V $\pm$ 10mV.

Note: This setting-up must be done on the test bench as switching on the drivers continuously when connected to the bus draws too much current and may overheat transistors.

RESULTS FROM MASTER CARD TESTS

	INPUT (VOLTS)	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
	CORRECT OUTPUT (VOLTS)	-10.0	-8.0	-6.0	-4.0	-2.0	0.0	2.0	4.0	6.0	8.0	10.0
ACTUAL OUTPUT OBTAINED (VOLTS)	Bin 0	-	-8.01	-6.02	-4.02	-2.01	-	1.93	-	5.91	7.91	9.82
	Bin 1	-	-8.03	-6.04	-4.02	-2.03	-0.04	1.95	3.95	5.94	7.93	-
	Bin 2	-	-8.03	-6.04	-4.02	-2.03	-0.10	1.95	3.93	5.90	7.89	9.82
	Bin 3	-	-8.03	-6.00	-4.00	-2.01	-0.02	1.97	3.96	5.96	7.93	9.82
	Bin 4	-	-8.01	-6.02	-4.08	-2.09	-0.12	1.89	3.69	5.72	7.79	9.79
	Bin 5	-	-8.01	-6.02	-4.02	-2.05	-0.06	1.93	3.91	5.88	7.87	9.75
	Bin 6	-9.98	-7.99	-6.00	-4.02	-2.05	-0.06	1.91	3.89	5.86	7.83	9.71
	Bin 7	-9.98	-7.97	-5.98	-4.00	-2.01	-0.04	1.95	3.93	5.90	7.87	9.75
	Bin 8	-	-8.01	-6.04	-4.04	-2.05	-0.08	1.89	3.89	5.86	7.83	9.75
	Bin 9	-	-8.03	-6.04	-4.04	-2.05	-0.08	1.91	3.89	5.84	7.83	9.75
	Bin 10	-9.98	-7.99	-6.00	-4.00	-2.03	-0.06	1.93	3.91	5.88	7.85	9.75
	Bin 11	-	-8.07	-6.07	-4.10	-2.13	-0.14	1.84	3.81	5.78	8.42	8.54
	Bin 12	-9.90	-7.89	-5.88	-3.87	-1.86	0.14	2.13	4.14	6.13	8.13	-
	Bin 13	-	-8.05	-6.04	-4.02	-2.01	-0.02	1.97	3.98	5.98	7.97	9.90
	Bin 14	-	-8.03	-6.02	-4.02	-2.01	0.00	1.97	3.96	5.96	7.95	9.88
	Bin 15	-	-8.09	-6.05	-4.04	-2.03	0.00	2.00	4.00	6.02	8.03	9.90

TABLE 1: RESULTS FROM MASTER CARD TESTS, JULY 1980. IN AUGUST 1980 ADJUSTMENTS WERE MADE TO THE 'BUS LEVEL' POTENTIOMETERS TO BRING ALL THE MASTER CARDS INTO LINE.

SECTION 4. INTERFACE BUFFER

The buffer utilizes the same instrumentation amplifier, AD 521, and in the same configuration as in the A/D converter module.

Adjustments

- Disconnect the analogue bus and connect extender cable instead.
- Short out analogue bus (PINS Y and Z) to ground (PIN X) and adjust offset to obtain an output of 0.00V.
- Connect +10V (referred to ground) to both inputs (PINS Y and X) and adjust balance to obtain 0.00V at the output.
- Connect 10.00 Volts between inputs and adjust gain to obtain 10.00V at the output.

Table 2: Correct Master Card Test Point Readings

Signal In	sits at +4.5 volts, changes when cards being addressed if near zero indicates one or more faulty amplifier cards
ZC	sits at logic 0 shows pulses when 'Zero Check' button depressed
EN	pulses
CE	sits at logic 0 goes to logic 1 when Master Card addressed
+15	+15 volts with respect to 'common'
-15	-15 volts with respect to 'common'
Common	Ground (0 volts)
Bus Y	sits at 0 volts
Bus Z	sits at 1.0 to 2.5 volts depending on the number of master cards connected to the bus. if zero indicates a mast er card somewhere in the system is faulty

PART IV

DISCUSSION OF SAMPLING SCHEMES

PART IV DISCUSSION OF SAMPLING SCHEMES

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SECTION 2 Aliasing and the Need for Filtering

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SECTION 1. INTRODUCTION

The Data Acquisition System is capable of sampling any sensor at any of the rates listed in Table 1, with the constraint that the total system sampling rate must not exceed 1765 samples/sec. In addition, the sampling mode on each sensor can be set on 'real' or 'peak holding'. The sampling rate and mode used for any particular sensor depends on the frequency content of the sensor output and on the nature of the information required, ie. mean values, peak values, etc.

Table 1

Sampling Rates available on the
Data Acquisition System

0: Not Sampled

1: Once Every 10 seconds

2: 1 Sample/Sec.

3: 10 Samples/Sec.

4: 50 Samples/Sec.

5: 100 Samples/Sec.

6: 250 Samples/Sec.

7: 500 Samples/Sec.

SECTION 2. ALIASING AND THE NEED FOR FILTERING

Aliasing is the effect whereby components on the original signal above the sampling frequency can appear in the sampled record as components below the sampling frequency. The details of the effect can be understood by consulting any book on time-series analysis. However, an example may prove illustrative and will be presented here because aliasing is a significant factor in recording strain gauge signals.

Consider the signal shown in Figure 1a: a sinusoid of frequency 750 Hz. This is sampled at 1000 Hz (sampling interval = 1 m sec.) producing a series of samples of varying voltage levels as shown by the arrows in Figure 1b. This is digitised and recorded on tape which is played back at a later date for analysis. If the analyst tries to reconstruct the original signal from the recorded samples he will obtain a 250 Hz wave form as shown in Figure 1c. In fact, in order to make this (albeit wrong) assessment he has to assume there are no high frequency components in the original signal. If you allow that there may be high frequency components present there are an infinite number of wave forms (see Figure 1d) that can be derived from the recorded samples.

The maximum frequency of a signal that can be reproduced using a sampling frequency, f_s, is given by

$$f_N = f_s/2$$

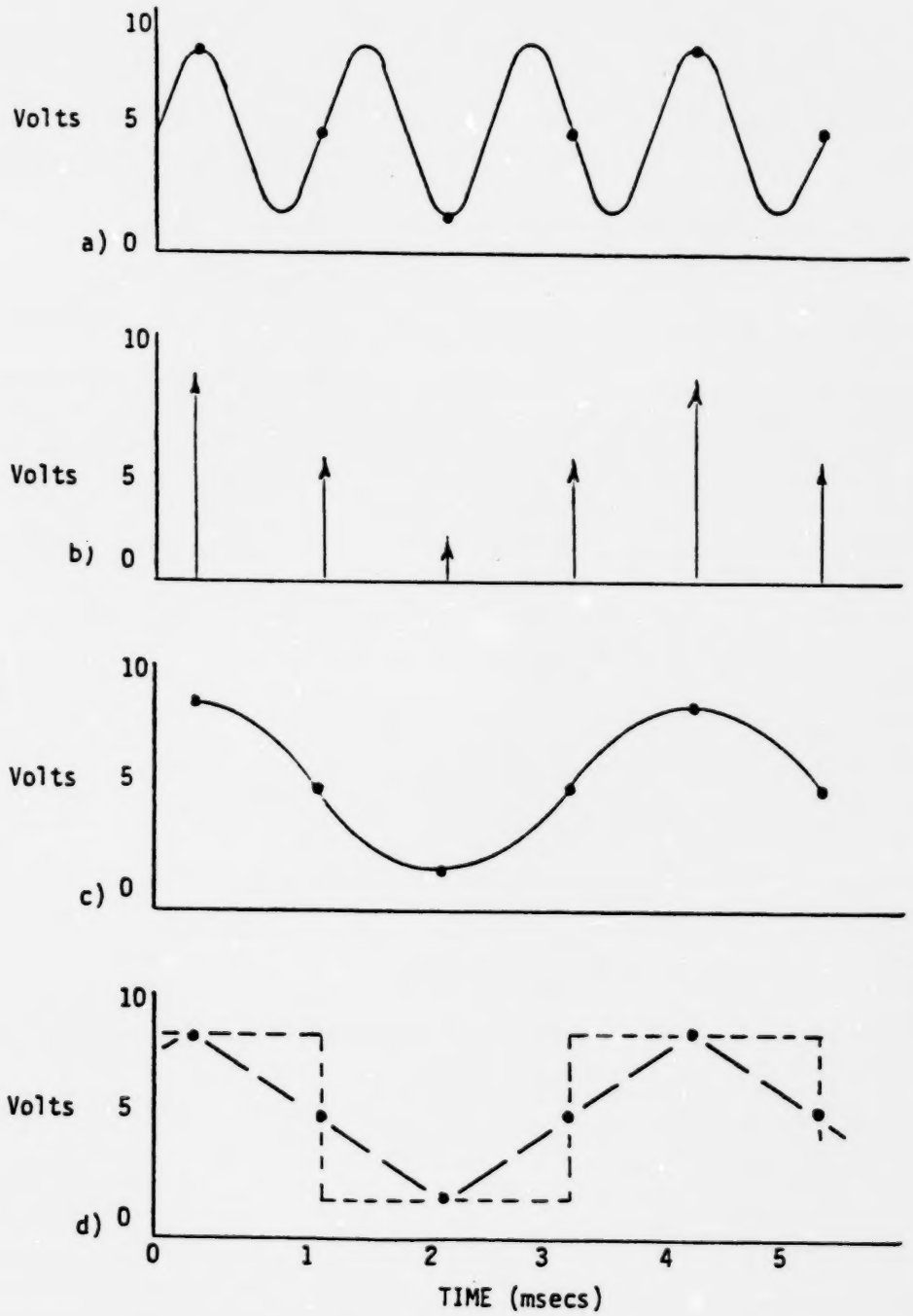

FIGURE 1: Example of the effects of aliasing

a) Original signal
b) Time of sampling and amplitude of each sample
c) Signal reconstructed from samples
d) Alternative signals obtained from samples.

where f_N is termed the Nyquist frequency. To avoid aliasing all components of the original signal above the Nyquist frequency have to be filtered out before sampling. It is impossible to obtain information from the sampled signal about components above the Nyquist frequency. Also, if there are significant high frequency components present in the original signal and they are not filtered out, information in the sampled record about components below the Nyquist frequency can be distorted or even lost completely.

Some signals do not have high frequency components and there is no worry about aliasing: for example, temperature varies over a matter of hours - very slow compared to the minimum sampling rate of once every 10 secs. Inertia of the sensors will damp out the high frequency components of some other signals, e.g. the pitch and roll gyro. Other sensors pick up a known high frequency component (e.g. vibration of the accelerometers) which can be filtered out to allow accurate measurements of low frequency components (e.g. rigid-body accelerations). However, in some cases (strain gauges) the amplitude of high frequency components in the signal are unknown. A classification of the signals recorded by the system according to their frequency content is shown in Table 2.

Table 2

EXPECTED FREQUENCY CONTENT OF MEASURED SIGNALS

Strain Gauges	Up to 600 Hz (at 5 knots0
Thermistors	Several Hours
Ship's Head	Several Seconds
Pitch and Roll	Several Seconds
Ship Speed	Several Seconds (in ice)
Accelerometers	Several Seconds (rigid body acceleration) Several Hundred Hz (vibration)
Propulsion and Steering	Several Seconds
Bubbler System	Several Seconds
Manual Inputs	Several Hours
Wind Speed	Mean Speed Varies Over Minutes Gusting Causes Brief (sec.) Speed Changes
Wind Direction	Mean Direction Varies Over Minutes Gusting Causes Brief (sec.) Direction Changes

SECTION 3. FILTERS AVAILABLE

To overcome aliasing problems some special cards were built with a low pass filter and an amplifier gain of 1. The filter cards are presently used with certain strain gauge channels and with the accelerometers, but could potentially be set to any corner frequency and used on any channel. The filter cards are modified amplifier cards: they can be addressed in the same way but all connections to pins 14, 15, 16 and 17 have been broken and the input now comes from a wander lead which can be plugged into the REAL test point of any selected amplifier card.

Selecting the 'real' or 'peak' output from an amplifier card effectively involves switching through the signal from output A (real) or output B (peak). On the filter cards output A gives the signal from a low pass filter with corner frequency f_1; while output B gives the signal from a low pass filter with corner frequency f_2. There is no 'peak detecting' option on the filter cards. Selecting the 'peak' output simply means selecting output B: the output of a particular filter.

The frequency characteristics of the filters available are shown in Figs. 2 and 3.

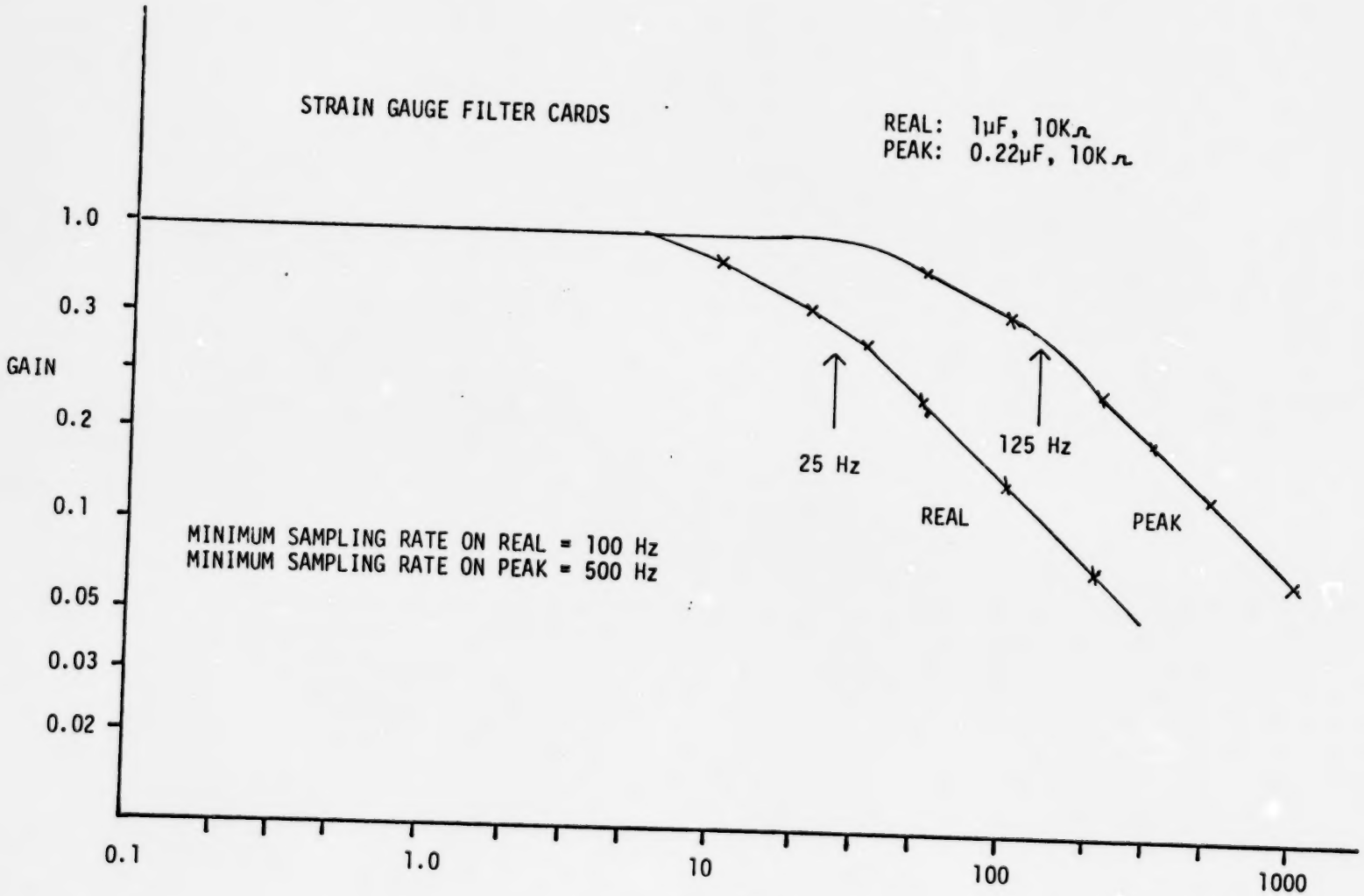
STRAIN GAUGE FILTER CARDS
REAL: 1μF, 10KΩ
PEAK: 0.22μF, 10KΩ
1.0
0.3
GAIN
0.2
0.1
0.05
0.03
0.02
25 Hz
125 Hz
REAL
PEAK
MINIMUM SAMPLING RATE ON REAL = 100 Hz
MINIMUM SAMPLING RATE ON PEAK = 500 Hz
0.1
1.0
10
100
1000
FREQUENCY (Hz)

FIGURE 2.

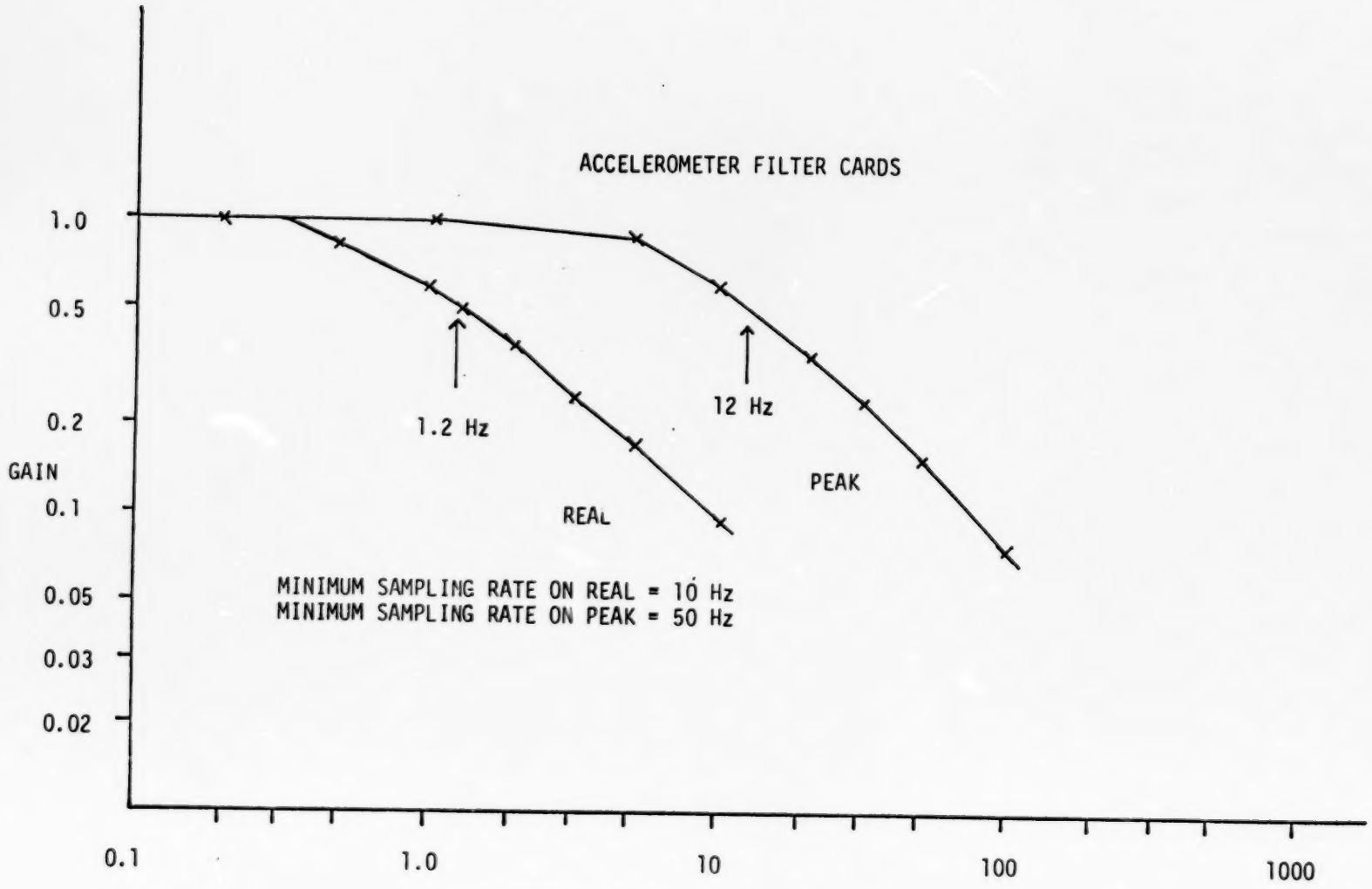
ACCELEROMETER FILTER CARDS
1.0
0.5
0.2
GAIN
0.1
0.05
0.03
0.02
1.2 Hz
12 Hz
REAL
PEAK
MINIMUM SAMPLING RATE ON REAL = 10 Hz
MINIMUM SAMPLING RATE ON PEAK = 50 Hz
0.1
1.0
10
100
1000
FREQUENCY (Hz)

FIG. 3.

SECTION 4. STRAIN GAUGES

The strain gauges are required to provide statistical and dynamic information on randomly occurring ice impacts, and selection of sampling rates to fulfill these requirements needs a knowledge of the typical durations of impacts. Preliminary analogue recordings of strains indicated that impacts lasted from 0.15 to 0.30 seconds and subsequent analysis of strain data confirmed this. Accordingly recording strains at 1 sample/sec., peak is assumed to give one higher-than-normal value for each impact. Inevitably some impacts will occur just as the gauge is being sampled so producing two high values; while two impacts may possibly occur within the one second so only giving a single high value; but these effects are not expected to distort the statistics on impact counts produced.

Thus, a simple count of the number of strain values above a certain level gives the number of ice impacts. In contrast, the use of higher sampling rates during the 1979 season necessitated the use of a time consuming 'impact-recognition' routine to produce a count of the ice impacts. However, it should be noted that through using the 'peak' mode no information is obtained regarding negative strains produced during ice impacts, and time resolution is no better than 1 sec.

Filters used with selected strain gauges provide high resolution data, of both positive and negative strains which can be used to measure impact rise

times and duration. Strain gauge filters should be recorded at 100 samples/sec, Real.

SECTION 5. SHIP PERFORMANCE SENSORS

The doppler log used to measure ship speed averages its measurements over several seconds and only updates its output every 15 seconds. Consequently, sampling at 1 sample/sec, Real or Peak will accurately record the ship speed.

To accurately monitor the pitch and roll and variations in the ship's heading recording at 10 samples/sec, Real, should prove sufficient. This enabled reproduction of the approx. 1 Hz flexing of the ship that was encountered in November 1980.

The stiffness of the ship and inertia of the water is expected to damp out higher frequency variations.

SECTION 6. ENVIRONMENTAL SENSORS

The outputs from the thermistors and manual inputs change very slowly and so a sampling rate of 1 sample/10 sec is adequate. No difference should result from using 'Real' or 'Peak' mode because no significant change in the sensor output will occur between samples.

To obtain a record of the average wind speed and direction in any period of 1 minute or longer, 1 sample/sec, real should be used. Use of 'peak' mode will distort the average but may be used if information is required on gusting.

SECTION 7. PROPULSION SENSORS

Both the mean value and the extreme values occurring in a period of 1 minute or longer may be required. To be sure of picking up positive extreme values with a slow sampling rate the peak mode has to be used. However, this may distort the mean value and will not record negative extremes. To ensure an accurate mean and to get both negative and postive extremes, real mode should be used and a faster sampling rate is probably needed.

To obtain average values only using 1 sample/sec, real is probably adequate.

To obtain extremes as well as average values 50 samples/sec, real is probably necessary.